WIRING METHODS AND MATERIALS

CHAPTER - 5

GENERAL WIRING REQUIREMENTS FOR WIRING METHODS

General Requirements:

(A) **All Wiring Installation.** This article covers general requirement for wiring methods and materials for all wiring installation unless modified by other articles in Chapter 3.

(B) **Integral Parts of Equipment.** The provisions of this article are not intended to apply to the conductors that form an integral part of equipment, such as motors, controllers, motor control centers, or factory assembled control equipment or listed utilization equipment.

(C) **Metric Designators and Trade Sizes.** Metric designators trade sizes for conduit, tubing and associated fittings and accessories shall be as designated in Table 3.0.1.1 (C).

Limitations:

(A) **Voltage.** Wiring methods specified in Chapter 3 shall be used for 1000 volts, nominal, or less where not specifically limited in some section of Chapter 3. They shall be permitted for over 1000 volts, nominal where specifically permitted elsewhere in this *Code.*

(B) **Temperature.** Temperature limitation of conductors shall be in accordance with 3.10.2.6 (A)(3).

Conductors

(A) **Single Conductors.** Single conductors specified in Table 3.10.3.1(A) shall only be installed where part of a recognized wiring method of Chapter 3.

(B) **Conductors of the Same Circuit.** All conductors of the same circuit where used, the grounded conductors and all equipment grounding conductors and bonding conductors shall be contained within the same raceway, auxiliary gutter, cable tray, cable bus assembly, trench, cable, or cord.

Protection Against Physical Damage. Where subject to physical damage, conductors, raceways, and cables shall be protected.

(A) Cables and Raceways Through Wood Members

(1) Bored Holes.

(2) Notches in Wood.

(B) Nonmetallic-Sheathed Cables and Electrical Nonmetallic Tubing Through Metal Framing Members.

(1) Non-metallic-Sheathed Cable.

(2) Nonmetallic-Sheathed Cable and Electrical Nonmetallic Tubing.

(C) Cables Through Spaces Behind Panels Designed to Allow Access.

(D) Cables and Raceways Parallel to Framing Members and Furring Strips.

(E) Cable, Raceways, or Boxes Installation in or Under Roof Decking.

(F) Cables and Raceways Installed in Shallow Grooves.

(G) Insulated Fittings.

(H) Structural Joints.

Underground Installation:

(A) **Minimum Cover Requirements.** Direct-buried cable or conduit or other raceways shall be installed to meet the minimum cover requirements of Table 3.0.1.5.

(B) **Wet Location.** The interior of enclosures or raceways installed underground shall be considered to be a wet location. Insulated conductors and cables installed in these enclosures or raceways in underground installation shall comply with 3.10.2.1(C).

(C) **Underground Cables and Conductors Under Building.** Underground cable and the conductors installed under a building shall be in raceway.

(D) **Protection from Damage.** Direct-buried conductors and cable shall be protected from damage in accordance with 3.0.1.5(D)(1) through (D)(4)

(1) Emerging from Grade.

(2) Conductors Entering Building.

(3) Service Conductors.

(4) Enclosure or Raceway Damage.

(E) **Splices and Taps.** Direct-buried conductors or cables shall be permitted to be spliced or tapped without the use of splice boxes.

(F) **Backfill**. Backfill that contains large rocks paving materials, cinders, large or sharply angular substances, or corrosive materials shall not be place in an excavation where materials may damage raceways, cables, conductors, or other substructure or prevent adequate compaction of fill or contribute to corrosion of raceways, cables, or other substructure.

(G) **Raceway Seals.** Conduits or raceways through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the insulation, conductor insulation, bare conductor, shield, or other components.

(H) **Bushing.** A bushing, or terminal fitting, with an integral bushed opening shall be used at the end of a conduit or other raceway that terminated underground where the conductors or cable emerge as a direct burial wiring method.

(I) **Conductors of the Same Circuit.** All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors shall be installed in the same raceway or cable or shall be installed in close proximity in the same trench.

(J) **Earth Movement.** Where direct-buried conductors, raceways, or cables are subject to movement by settlement or frost, direct-buried conductors raceways or cables shall be arranged so as to prevent damage to the enclosed conductors or to equipment connected to the raceways.

(K) **Directional Boring.** Cables or raceways installed using directional boring equipment shall be approved for the purposes.

Protection Against Corrosion and Deterioration:

A) **Ferrous Metal Equipment.** Ferrous metal raceways, cable trays, cable bus, auxiliary gutters, cable armor, boxes, cable sheathing, cabinets, metal elbows, and the likes shall be suitably protected against corrosion inside and outside by a coating of approved corrosion-resistant material.

B) **Aluminum Metal Equipment.** Aluminum raceways, cable trays, cable bus, auxiliary gutters, cable armor, boxes, cable sheathing, cabinets, elbow, couplings, nipples, fittings, supports, and support hardware embedded or in case in concrete or in direct contact with the earth shall be provided with supplementary corrosion protection.

(C) Nonmetallic Equipment.

(1) Exposed to Sunlight

(2) Chemical Exposure

(D) Indoor Wet Locations. In portion of dairy processing facilities, laundries, canneries, and other indoor wet locations, and in locations where walls are frequently washed or where there are surfaces of absorbent materials

Raceway Exposed to Different Temperatures:

(A) **Sealing.** Where portions of raceway or sleeve are known to be subjected to different temperatures, and where condensation is known to be a problem, as in cold storage areas of buildings or where passing from the interior to the exterior of a building, the raceway o sleeve shall be filled with an approved material to prevent the circulation of warm air to a colder section of the raceway or sleeve

B) **Expansion, Expansion-Deflection and Deflection Fittings.** Raceways shall be provided with expansion, expansion-deflection, deflection fittings where necessary to compensate for thermal expansions, deflection and contraction.

Installation of Conductors with other System. Raceways or cable trays containing electrical conductors shall not contain any pipe, tube, or equal for steam, water, air, gas, drainage, or any service other than electrical

Raceways in Wet Locations Abovegrade. Where raceways are installed in wet locations abovegrade, the interior of these raceways shall be considered to be a wet locations.

Electrical Continuity of Metal Raceways and Enclosures. Metal raceway, cable armor and other metal enclosures for conductors shall be metallically joined together into a continuous electrical conductor and shall be connected to all boxes, fittings, and cabinets

Securing and Supporting:

(A) **Secured in Place.** Raceways, cable assemblies, boxes, cabinets, and fitting shall be securely fastened in place.

(B) **Wiring Systems Installed Above Suspended Ceilings.** Support wires that do not provide secure support shall not be permitted as the sole support.

(1) Fire-Rated Assemblies

(2) Non-Fired-Rated Assemblies

(C) **Raceways Used as Means of Support.** Raceways shall be used only as a means of support for other raceway, cables, or nonelectrical equipment.

(D) **Cables Not Used as Means of Support.** Cable wiring methods shall not be used as a means of support for other cables, raceways, or nonelectrical equipment.

Mechanical Continuity-Raceways and Cables:

(A) **General.** Conductors in raceways shall be continuous between outlets, boxes, devices, and so forth. There shall be no splice or tap within raceway

(B) **Device Removal.** In multiwire branch circuits, the continuity of a grounded conductor shall not depend on device connection such as lamp holders, receptacles, and so forth

Length of Free Conductors at Outlets, Junctions, and Switch Points:

At least 150 mm of free conductor measured from the point in the box where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point for splices or the connection of luminaires or devices.

Boxes, Conduit bodies, or Fitting-Where Required:

(A) **Wiring Method with Interior Access.** A box or conduit body shall not be required for each splice, junction, switch, pull, termination, or outlet points in wiring methods with removable covers.

(B) **Equipment.** An integral junction box or wiring compartment as part of approved equipment shall be permitted in lieu of a box

(C) **Protection.** A box or conduit body shall not be required where cables enter or exit from conduit or tubing that is used to provide cable support or protection against damage.

(D) **Type MI Cable.** A box or conduit shall not be required where accessible fittings are used for straight-through splices in mineral-insulated metal-sheathed cable.

(E) **Integral Enclosure**. A wiring device with integral enclosure identified for the use, having brackets that are securely fasten the device to walls or ceiling of conventional on-site frame construction, for use with nonmetallic-sheathed cable, shall be permitted in lieu of a box or conduit body.

(F) **Fitting**. A fitting identified for the use shall be permitted in lieu of a box or conduit body where conductors are not spliced or terminated within the fitting.

(G) **Direct-Buried Conductors**. a box or conduit body shall not be required for splices and taps in direct-buried conductors and cables.

(H) **Insulated Devices.** a box or conduit body shall not be required for insulated devices supplied by nonmetallic-sheathed cable.

(I) **Luminaires.** A box or conduit body shall not be required where a luminaire is used as a raceway.

(K) **Embedded.** A box or conduit shall not be required for splices where conductors are embedded

(L) **Manholes and Handhold Enclosures.** A box or conduit body shall not be required for conductors in manholes or hand holes enclosures, except where connecting to electrical equipment .

Raceway or Cable to Open or Concealed Wiring:

(A) **Box, Conduit Body, or Fitting.** A box, conduit body, or terminal fitting having a separately bushed hole for each conductor shall be used wherever a change is made from conduit, raceway wiring to open wiring or to concealed knob-and-tube- wiring.

(B) **Bushing.** A bushing shall be permitted in lieu of a box or terminal where the conductors emerge from a raceway and enter to terminate at equipment, such as open switchboards, unenclosed control equipment, or similar equipment.

Raceway Installation:

(A) **Complete Runs.** Raceways, other than or exposed raceways having hinged or removable covers, shall be installed complete between outlet, junction, or splicing points prior to the installation of conductors.

(B) **Welding.** Metal raceways shall not be supported, terminated, or connected by welding to the raceway unless specifically designed to be or otherwise specifically permitted to be in this *Code*.

Supporting Conductors in Vertical Raceways:

(A) **Spacing Intervals-Maximum**. Conductors in vertical raceways shall be supported if the vertical rise exceeds the values in Table provided accordingly.

(B) **Fire-Rated Cables and Conductors**. Support methods and spacing intervals for fire-rated cables and conductors shall comply with any restrictions provided in the listing of the electrical circuit protective system used and in no case shall exceed the values in Table provided accordingly.

Table 3.0.1.19(A) Spacing for Conductor Supports:

Size of Wire mm^2 (mm dia.)	Support of Conductors in Vertical Raceways	Conductors	
		Aluminum or Copper Clad Aluminum (m)	Copper (m)
0.75(1.0) through 8.0(3.2)	Not greater than	30	30
14 through 50	Not greater than	60	30
60 through 100	Not greater than	55	25
Over 100 through 175	Not greater than	40	18
Over 175 through 250	Not greater than	35	15
Over 250 through 400	Not greater than	30	12
Over 400	Not greater than	25	11

Induces Current in Ferrous Metal Enclosure or Ferrous Metal Raceways:

(A) **Conductors Grouped Together**. Where conductors carrying alternating current are installed in ferrous metal enclosure or ferrous metal raceways, they shall be arranged so as to avoid heating the surrounding ferrous metal by induction.

(B) **Individual Conductors**. Where single conductor carrying alternating current, the inductive effects shall be minimized by

(1) cutting slots in the metal between the individual holes

(2) passing all the conductors in the circuit through an insulating wall large enough for the conductors to pass through.

Spread of Fire or Products of Combustion:

(A) **Ducts for Dust, Loose Stock, or Vapor Removal**. No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapor.

(B) **Ducts Specifically Fabricated for Environmental Air.** Equipment, devices and the wiring methods specified in this section shall be permitted within such ducts only if necessary for the direct action upon or sensing of the contained air.

(C) **Other Spaces Used for Environmental Air(Plenums)** This section shall apply to spaces not specifically fabricated for environmentally air-handling purposes but used for air-handling purposes as a plenum.

Wiring Methods. The wiring methods for such other space shall be limited to totally enclosed, nonventilated, insulated bus way having no provisions for plug-in connections.

Equipment. Electrical equipment with a metal enclosure or electrical equipment with a non-metallic enclosure listed for used within air – handling space shall be permitted to be installed in such other space unless prohibited elsewhere in this code

Panels Design to Allow Access. Cables, raceway, and equipment installed behind panels designed to allow access, including suspended ceiling panels shall be arranged and secured so as to allow the removal of panels and access to the equipment.

Requirements for over 1000 Volts, Nominal Covers Required. Suitable covers shall be installed on all boxes, fitting and similar enclosures to prevent accidental contact with energize parts or physical damage to parts or insulation.

Conductor Bending Radius. The conductor shall NOT BE BENT to a radius less than 8 TIMES the over all diameter for no shielded conductors or 12 TIMES the over all diameter for shielded or lead covered conductors during or after installation.

Protection Against Induction Heating. Metallic raceway and associated conductors shall be arranged so as to avoid heating of the

Aboveground Wiring Methods. Aboveground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in electrical metallic tubing.

Raceway in Wet Location Above Grade. Where raceway are installed in wet location above grade, the interior of these race shall be considered to be a wet location .

Insulation Shielding. Metallic and semiconducting insulation shielding components of shielded cables shall be removed for a distance dependent on the circuit voltage and insulation.

Moisture or Mechanical Protection for Metal-Sheathed Cables. Where cables conductors emerge from a metal sheath and where protection against moisture or physical damage is necessary.

Warning Signs. Warning signs shall be conspicuously posted at points of access to conductors in all conduits systems and cable system.

DANGER-HIGH VOLTAGE-KEEP OUT:

UNDERGROUND INSTALLATIONS:

(A) **General**. Underground conductor shall be identified for the voltage and condition under which they are installed.

(B) **Wet Location**. The interior of enclosure or raceways installed underground shall be considered to be a wet location.

(C) **Protection from Damage**. Conductors emerging from the ground shall be enclosed in listed raceways

(D) **Splices**. Direct burial cables shall be permitted to be spliced or tapped without the use of splice boxes, provided they are installed using material suitable for the application.

(E) **Backfill.** Backfill containing large rocks, paving materials, cinders, large or sharply angular substances or corrosive materials shall not be placed in an excavation where material can damage.

(F) **Raceway Seals.** Where a raceway enters from an underground system, in the end the building shall be sealed with an identified compound so as to prevent the entrance of moisture or gases.

CONDUCTORS FOR GENERAL WIRING

Electrical Ducts. Electrical conduits, or other raceways round in cross section, that are suitable for use underground or embedded in concrete.

Thermal Resistivity. The heat transfer capability through a substance by conduction.

(1) **General**. Aluminum, copper-clad aluminum, or copper conductors, for each phase, polarity, neutral, or grounded circuit shall be permitted to be connected in parallel

(2) **Conductor and Installation Characteristics**. Installation for the paralleled conductors shall comply with all of the following:

(1) Be the same length

(2) Consist of the same conductor material.

(3) Be the same size in square millimeter area.

(4) Have the same insulation type.

(5) Be terminated in the same manner

(3) **Separate Cables or Raceways**. Where run in separate cables or raceways with conductors shall have the same number of conductors and shall have the same electrical characteristics.

(4) **Ampacity Adjustment.** Conductors installed in parallel shall comply with the provisions of 3.10.2.6(B)(3)(a).

(5) **Equipment Grounding Conductors.** Where parallel equipment grounding conductors are used, they shall be sized in accordingly. Sectioned equipment grounding conductors smaller than 50 mm^2 shall be permitted in multiconductor cables, if the combined square millimeter area of the sectioned equipment bonding conductors in each cable compiles with 2.50.6.13.

(6) **Bonding Jumpers.** Where parallel equipment bonding jumpers or supply-side bonding jumpers are installed in raceways, they shall be sized and installed in accordance with 2.50.5.13.

Ampacities for Conductors Rated 0-2000 Volts:

(A) General.

- No conductor shall be used in such manner that its operating temperature exceeds that designated for the type of insulated conductor involved.
- In no case shall conductors be associated together in such a way, with respect to type of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of any conductor is exceeded.
- The temperature correction and adjustment factors shall be permitted to be applied to the ampacity for the temperature rating of the conductor, if it does not exceeded the ampacity for the temperature rating of the termination in accordance with the provisions of 1.10.1.114(C).

(B) Ambient Temperature Correction Factors.

Ampacities for ambient temperatures other than those shown in the ampacity tables shall be corrected in accordingly or shall be permitted to be calculated using the following equation:

$$I' = \sqrt{\frac{(T_c - T'_a)}{(T_c - T_a)}}$$

Where:

I' = ampacity corrected for ambient temperature

I = ampacity shown in the tables

T_c = temperature rating of conductor (°C)

T'_a = new ambient temperature (°C)

T_a = ambient temperature used in the table

Bare or Covered Conductors For bare or covered conductors are installed with insulated conductors, the temperature rating of the bare or covered conductor shall be equal to the lowest temperature rating of the insulated conductors for the purpose of determining ampacity.

Neutral Conductor.

- A neutral conductor that carries only the unbalanced current shall not be required to be counted when applying the provisions

Neutral Conductor.

- A 3-wire circuit consisting of two phase conductors and the neutral conductor pf a 4-2ire, 3-phase, wye connected system, a common conductor carries approximately the same current as the line-to-neutral load currents of the other conductors and shall be counted also.
- On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, harmonic currents are present in the neutral conductor; the neutral conductor shall therefore be considered a current-carrying conductor.

Grounding or Bonding Conductor. A grounding or bonding conductors shall not be counted when applying the provisions of 3.10.2.6(B)(3)(a).

Single-Phase Dwelling Services and Feeders. For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, service and feeder conductors supplied by a single-phase, 115/230-volt system shall be permitted be sized in accordance with 3.10.2.6(B)(7)(1) through (4).

(C) **Engineering Supervisions.** Under engineering supervisions, conductor ampacities shall be permitted to be calculated by means of the following general equation:

$$I' = \sqrt{\frac{(T_c - T_a)}{R_{dc}(1 + Y_c)R_{ca}}} x10^3 \ Amperes$$

Where:

T_c = *conductor temperature in degrees Celsius*

T_a = *ambient temperature in degrees Celsius*

R_{dc} = *dc resistance of 300 mm of conductor in microohms at temperature,* T_c

Y_c = *component ac resistance resulting from skin effect and proximity effect*

R_{ca} = *effective thermal resistance between conductor an surrounding ambient*

Conductors Rated 2001 to 35000 Volts:

(A) Ampacities of Conductors Rated 2001 to 35000 Volts

(B) **Engineering Supervision.** Under engineering super visions, conductor ampacities shall be permitted to be calculated by means of the following general equation:

$$I = \sqrt{\frac{(T_c - (T_a - \Delta T_d))}{R_{dc}(1 + Y_c)R_{ca}}} x10^3 \ \ Amperes$$

Where

T_c = conductor temperature
T_a = ambient temperature
ΔT_d = dielectric loss temperature rise
R_{dc} = dc resistance of conductor at temperature Tc
Y_c = component ac resistance resulting from skin effect and proximity effect
R_{ca} = effective thermal resistance between conductor and surrounding ambient

(C) Tables.

*(1) **Grounded Shields.** Ampacities shown in the table 3.10.2.51(C)(69), Table 3.10.2.51(C)(70), Table 3.10.2.51(C)(81), and Table 3.10.2.51(C)(82) shall apply for cables with shields grounded at one point only. Where shields for these cables are grounded at more than one point, ampacities shall be adjusted to take into considerations the heating due to shield currents*

*(2) **Burial Depth of Underground Circuits.** Where the burial depth of direct burial or electrical duct bank circuits is modified from the values shown in a figure or table, ampacities shall be permitted to be modified as indicated in (C)(2)(a) and (C(2)(b).*

(3) **Ambient Temperature Correction.** Ampacities for ambient temperatures other than those specified in the ampacity tables shall be corrected in accordance with Table 3.10.2.51(C)(4) or shall be permitted to be calculated using the following equation:

$$I' = \sqrt{\frac{(T_c - T'_a)}{(T_c - T_a)}}$$

Where:

I' = ampacity corrected for ambient temperature

I = ampacity shown in the table for T_c and T_a

T_c = temperature rating of conductor

T'_a = new ambient temperature

T_a = ambient temperature used in the table

Table 3.10.2.6 (B)(2)(b) Ambient Temperature Correction Factors Based on 40°C

For ambient temperatures other than 40°C, multiply the allowable ampacities specified in the ampacity tables by the appropriate correction factor shown below.							
Ambient Temperature (°C)		Temperature Rating of Conductor					
		60°C	75°C	90°C	150°C	200°C	250°C
	10 or less	1.58	1.36	1.26	1.13	1.09	1.07
	11 - 15	1.5	1.31	1.22	1.11	1.08	1.06
	16 - 20	1.41	1.25	1.18	1.09	1.06	1.05
	21 - 25	1.32	1.2	1.14	1.07	1.05	1.04
	26 - 30	1.22	1.13	1.1	1.04	1.03	1.02
	31 - 35	1.12	1.07	1.05	1.02	1.02	1.01
	36 - 40	1	1	1	1	1	1
	41 - 45	0.87	0.93	0.95	0.98	0.98	0.99
	49 - 50	0.71	0.85	0.89	0.95	0.97	0.98
	51 - 55	0.5	0.76	0.84	0.93	0.95	0.96
	56 - 60	-	0.65	0.77	0.9	0.94	0.95
	61 - 65	-	0.53	0.71	0.88	0.92	0.94
	66 - 70	-	0.38	0.63	0.85	0.9	0.93
	71 - 75	-	-	0.55	0.83	0.88	0.91
	76 - 80	-	-	0.45	0.8	0.87	0.9
	81 - 90	-	-	-	0.74	0.83	0.87
	91 - 100	-	-	-	0.67	0.79	0.85
	101 - 110	-	-	-	0.6	0.75	0.82
	111 - 120	-	-	-	0.52	0.71	0.79
	121 - 130	-	-	-	0.43	0.66	0.76
	131 - 140	-	-	-	0.3	0.61	0.72
	141 - 160	-	-	-	-	0.5	0.65
	161 - -180	-	-	-	-	0.35	0.58
	181 - 200	-	-	-	-	-	0.49
	201 - 225	-	-	-	-	-	0.35

CABINETS, CUT-OUT BOXES, AND METER SOCKETS ENCLOSURE

Metal Cabinets, Cut-out Boxes, and Meter Sockets Enclosure:

Where metal enclosures within the scope of this article are installed with messenger-supported wiring, open wiring on insulators, or concealed knob-and-tube wiring, conductors shall enter through insulating bushings or, in dry locations, through flexible tubing extending from the last insulating support and firmly secured to the enclosure.

Cables:

Where cable is used, each cable shall be secured to the cabinet, cut-out box, or meter socket enclosure.

Exception: Cables with entirely non-metallic sheaths shall be permitted to enter the top of a surface-mounted enclosure through one or more nonflexible raceways not less than 450 mm and not more than 3000 mm in length, provided all of the following conditions are met:

a. Each cable is fastened within 300 mm, measured along the sheath, of the outer end of the raceways.

b. The raceways extends directly above the enclosure and does not penetrate a structural ceiling.

c. A fitting is provided on each end of the raceways to protect the cable from abrasion and the fittings remain accessible after installation.

d. The raceway is sealed or plugged at the outer end using approved means as to prevent access to the enclosure through the raceways.

e. The cable sheath is continuous through the raceway and extends into the enclosure beyond the fitting not less than 6mm.

f. The raceways is fastened at its outer end and at other points in accordance with the applicable article.

g. Where installed as conduit or tubing, the cable fill does not exceed the amount that would be permitted for complete conduit or tubing system.

Definition of Conductors:

A. Width Wiring

B. Wire-Bending Space at Terminals

1. Conductors Not Entering or Leaving Opposite Wall
2. Conductors Entering or Leaving Opposite Wall

C. Conductors 22mm^2 *or Larger*

D. Space Enclosure

Cabinets and cut-out boxes shall have approved space to accommodate all conductors installed in them without crowding.

Switch and Overcurrent Device Enclosures:

The wiring space within enclosures for switches and over current devices shall be permitted for other wiring and equipment subject to limitations for specific equipment as provided in (A) and (B).

A. Splices, Tops, and Feed-Through Conductors

B. Power Monitoring Equipment

Side or Back Wiring Spaces or Gutters

Cabinets and cut-out boxes shall be provided with back-wiring spaces, gutters, or wiring compartments as required by Construction Specifications (C) and (D).

Conductors Specification:

1. Materials
    a. Metal Cabinets or Cut-out Boxes
    b. Strength
    c. Non-metallic Cabinets

Spacing:

A. General

* Base
* Doors
* Live Parts
* Wiring Space-Enclosure

B. Switch Clearance

C. Wiring Space

D. Wiring Space-Enclosure

OUTLET, DEVICES, PULL AND JUNCTION BOXES; CONDUIT BODIES; FITTINGS AND HANDHOLE ENCLOSURES

Scope and General:

A. Round Boxes
B. Scope
C. Non-metallic Boxes
D. Metal Boxes

Installations:

A. Damp or Wet Locations
B. Number of Conductors in Outlet, Device and Junction Boxes, and Conduit Bodies
    a. Box Volume Calculations
        *Standard Boxes
        *Other Boxes

b. Box Fill Calculations

*Conductor Fill

*Clamp Fill

*Support Fittings Fill

*Device or Equipment Fill

*Equipment Grounding Conductor Fill

c. Conduit Bodies

*General

*With Splices, Tops, or Devices

*Short Radius Conduit Bodies

Conductors Entering Boxes, Conduit Bodies, or Fittings:

1. Volume Allowance Required per Conductor

Size of Conductor mm^2 (mm dia.)	Free Space Within Box for each Conductor cm^3
0.75(1.0)	24
1.25(1.2)	28
2.0(1.6)	32
3.5(2.0)	36
5.5(2.6)	40
8.0(3.2)	50
14	82

Boxes Enclosing Flush Devices:

- Boxes used to enclose flush devices shall be of such design that the devices will be completely enclosed on back and sides and substantial support for the devices will be provided.
- Screws for supporting the box shall not be used in attachment of the device contained therein.

Flush-Mounted Installation:

- Installations within or behind a surface of concrete, tile, gypsum, plaster, or other non-combustible materials, boxes employing a flush-type cover of faceplate shall be made so that the front edge of the box, plaster ring, extension ring, or listed extender will not be set back of the finished surface more than 6 mm.

Repairing Non-Combustible Surfaces:

- Non-combustible surfaces that are broken or incomplete round boxes employing a flush-type cover or faceplate shall be repaired so there will be no gasp or open spaces greater than 3 mm at the edge of the box.

Surface Extensions:

Surface extensions shall be made by mounting and mechanically securing an extension ring over the box.

Supports:

1. Surface Mounting
2. Structural Mounting
   a. Nails and Screws
   b. Braces
   c. Mounting in Finished Surface
   d. Suspended Ceilings
      *Framing Members
      *Support Wires

Surface Extensions:

Supports :

2. Structural Mounting
    e. Raceway-Supported Enclosure, Devices Luminaires, or Lamp Holders
    f. Raceway-Supported Enclosures, with Devices, Luminaires or Lamp Holders
    g. Enclosures in Concrete or Masonry
    h. Pendant Boxes
        *Flexible Chord
        *Conduit

Depth of Boxes:

A. Outlet Boxes without Enclosed Devices or Utilization Equipment

B. Outlet and Device Boxes with Enclosed Devices or Utilization Equipment

   a. Large Equipment

   b. Conductors Larger than 22mm^2

   c. Conductors 8, 14, or 22mm^2

   d. Conductors 3.5 or 5.5mm^2

   e. Conductors 2.0mm^2 (1.6mm dia.) and smaller

Covers and Canopies

A. Non-metallic or Metal Covers and Plates
B. Exposed Combustible Wall or Ceiling Finish
C. Flexible Cord Pendants

Outlet Boxes:

A. Boxes at Luminaire or Lamp Holder Outlets

    a. Vertical Surface Outlets

    b. Ceiling Outlets

B. Floor Boxes

C. Boxes at Ceiling-Suspended (paddle) Fan Outlets

D. Utilization Equipment

E. Separable Attachment Fittings

Pull and Junction Boxes and Conduit Bodies:

A. Minimum size
    a. Straight Pulls
    b. Angle or U-Pulls, or Splices
    c. Smaller Dimensions
B. Conductor in Pull or Junction Boxes
C. Covers
D. Permanent Barriers
E. Power Distributions Blocks
    a. Installation
    b. Size
    c. Wire Bending Space
    d. Live Parts
    e. Through Conductors

Boxes, Conduit Bodies, and Handhole Enclosures to be Accessible:

A. Hand hole Enclosure

a. Size

b. Wirings Entries

c. Enclosed Wiring

d. Cover

Construction Specification:

1. Metal Boxes, Conduit Bodies, and Fittings
    a. Corrosion Resistant
    b. Thickness of Metal
    c. Metal Boxes Over 1650 cm^3
    d. Grounding Provisions
2. Covers
3. Bushings
4. Non-Metallic Boxes
5. Marking

ARMORED CABLE: TYPE AC

Uses Permitted:

Type AC cable shall be permitted as follows:

(1) For feeders and branch circuits in both exposed and concealed installations

(2) In cable trays

(3) In dry locations

(4) Embedded in plaster finish on brick or other masonry, except in damp or wet locations

(5) To be run or fished in the air voids of masonry block or tile walls were such walls are not exposed or subject to excessive moisture or dampness.

Uses Not Permitted:

Type AC cable shall not be used as follows:

(1) Subject to physical damage

(2) Wet locations

(3) Tile walls where such walls are exposed to excessive moisture dampness

(4) Exposed to corrosive conditions

(5) Embedded in plaster finish on brick

Exposed Work:

- Exposed runs of cable shall be closely follow the surface of the building finish or of running boards.
- Exposed runs shall also be permitted to be installed on the underside of joists where supported at each joist and located so as not to be subject to physical damage.

Through or Parallel to Framing Members:

Type AC cable shall be protected in accordance with 3.0.1.4 (A),(C) and (D) where installed through or parallel to framing members.

In Accessible Attics:

Type AC cables in accessible attics or roof spaces shall be Installed as specified in 3.20.2.14(A) and (B).

(A) Cables Run Across the Top of Floor Joists:

- *Where run across the top of floor joists, or within 2100 mm of the floor*
- *The cable shall be protected by guard strips that are at least as high as the cable*
- *Where this space is not accessible by permanent stairs or ladders, protection shall only be required within 1800 mm of the nearest edge of the scuttle hole or attic entrance.*

(B) Cable Installed Parallel to Framing Members: Where the cable is installed parallel to the sides of rafters, studs, or ceiling or floor joists, neither guard strips nor running boards shall be required.

Bending Radius:

- *Bends in Type AC cable shall be made such that the cable is not damaged. The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the Type AC cable.*

Securing and Supporting:

(A) General.

- Type AC cable shall be supported and secured by staples, cable ties listed and identified for securement support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage the cable.

Securing and Supporting:

(B) Securing

- Unless otherwise permitted, Type AC cable shall be secured within 300 mm of every outlet box, cabinet or fitting and at intervals not exceeding 1400 mm where installed on or across framing members.

Securing and Supporting:

(C) Supporting.

- *Unless otherwise permitted, Type AC cable shall be supported at intervals not exceeding 1400 mm.*
- *Horizontal runs of Type AC cable installed in wooden or metal framing members or similar supporting means shall be considered supported where such support does not exceed 1400-mm intervals.*

(D) Unsupported Cables. Type AC cable shall be permitted to be unsupported and unsecured where the cable complies with any of the following:

(1) Is fished between access points through concealed spaces in finished buildings

(2) Is not more than 600 mm in length at terminals where flexibility is necessary

(3) Is not more than 1800 mm in length from the last point of cable support to the point of connection to a luminaire(s) or other electrical equipment and the cable and point of connection are within an accessible ceiling. For the purposes of this section,

Boxes and Fittings:

- A fitting shall be provided to protect wires from abrasion, unless the design of the outlet boxes or fittings is such as to afford equivalent protection
- An insulating bushing shall be provided between the conductors and the armor. The connector by which the Type AC cable is fastened to boxes shall be of such design that the insulating bushing will be visible for protection.
- Where change is made from Type AC cable to the other cable or raceway wiring methods; a box, fitting or conduit body shall be installed at junction points.

Ampacity:

The Ampacity shall be determined in accordance with 3.10.2.6.

(A) **Thermal Insulation.**

- *Armored cable installed in thermal insulation shall have conductors rated at 90°C.*
- *Ampacity of the cable installed shall not exceed that of a 60°C rated conductor*

(B) **Cable Tray.** The ampacity of Type AC cable installed in the cable tray shall be determined in accordance with 3.92.2.71(A).

Construction Specifications:

Construction.

Type AC cable shall have an armor of flexible metal tape and shall have an internal bonding strip of copper or aluminum in intimate contact with the armor for its entire length.

Conductors.

The conductors shall have an overall moisture-resistant *and fire-retardant fibrous covering on the individual conductors.*

Equipment Grounding Conductor:

- Type AC cable shall provide an adequate path for fault current as required by 2.50.1.4(A)(5) or (B)(4) to act as an equipment grounding conductor.

Marking:

- The cable shall be marked in accordance with 3.10.3.17, except that Type AC shall have ready identification of manufacturer by distinctive external markings on the cable armor throughout its entire length.

FLAT CABLE ASSEMBLIES: TYPE FC

General:

Definition.

Flat Cable Assembly, Type FC. An assembly of parallel conductors formed integrally with an insulating material web specifically designed for field installation in surface metal raceway.

Listing Requirements. Type FC and associated fittings shall be listed.

Uses Permitted:

(1) As branch circuits to supply suitable tap devices for lighting, small appliances, or small power loads. The rating of the branch circuit shall not exceed 30 amperes.

(2) Where installed for exposed work.

(3) In locations where they will not be subjected to physical damage. Where a flat assembly is installed less than 2 500 mm above the floor, it shall be protected by a cover identified for use.

(4) In surface metal raceways identified for the use.

Uses Not Permitted:

(1) Where exposed to corrosive conditions

(2) In hoistways or on elevators or escalators

(3) In any hazardous (classified) location

(4) Outdoors or in wet locations

Securing and Supporting:

- The flat cable assemblies shall be supported by means of their special design features, within the surface metal raceways.
- The surface metal raceways shall be supported as required for the specific raceway to be installed.

Boxes and Fittings:

(A) **Dead Ends.** Each cable flat assembly dead end shall be terminated in an end-cap device identified for the use.

(B) **Luminaire Hangers.** Luminaire hangers installed with the flat cable assemblies shall be identified for the use.

(C) **Fittings.** Fittings to be installed with flat cable assemblies shall be designed and installed to prevent physical damage to the cable assemblies.

(D) **Extensions.** All extensions from flat cable assemblies shall be made by approved wiring methods, within the junction boxes, installed at either end of flat cable assembly runs.

Splices and Taps:

(A) **Splices.** Splices shall be made in listed junction boxes.

(B) **Taps.** Taps shall be made between any phase conductor and the grounded conductor by means of devices and fittings identified for the use. Tap devices shall be rated at not less than 15 amperes, or more than 300 volts to ground, and shall be color-coded.

Construction Specifications:

Construction. Flat cable assemblies shall consist of two, three, four or five conductors.

Conductors. Flat cable assemblies shall have conductors of 5.5 mm^2 (2.6 mm dia.) special stranded copper wires.

Insulation. The entire flat cable assembly shall be formed to provide a suitable insulation covering all the conductors.

Marking:

(A) Temperature Rating.

Type FC cable shall have temperature rating durably marked on the surface at intervals not exceeding 600 mm.

(B) Identification of Grounded Conductor.

The grounded conductor shall be identified throughout its length by means of a distinctive and durable white or gray marking.

(C) Terminal Block Identification.

- Shall have distinctive and durable markings for color or word coding.
- The grounded conductor shall have a white marking
- The next adjacent section of the terminal block shall have a black marking.
- The next section shall have a red marking
- The final outer section, opposite the grounded conductor section of terminal block, shall have a blue marking.

FLAT CONDUCTOR CABLE: TYPE FCC

- **BOTTOM SHIELD.** A protective layer that is installed between the floor and Type FCC flat conductor cables to protect the cable from physical damage and may or may not be incorporated as an integral part of the cable.
- **CABLE CONNECTOR.** A connector designed to join Type FCC cables without using a junctions box.
- **FCC SYSTEM.** A complete wiring system that is designed for installation under carpet squares.

- **METAL SHIELD CONNECTION.** Means of connection designed to electrically and mechanically connect to metal shield , to a receptacle housing or self-contained device, or to a transition assembly.
- **TOP SHIELD.** A grounded metal shield covering under carpet components of the FCC system for the purpose of providing protection against physical damage.

- **TRANSITION ASSEMBLY.** An assembly to facilitate connection of the FCC system to the other wiring system incorporating (1) a means of electrical interconnection and (2) a suitable box or covering for providing electrical safety and protection against physical damage.
- **TYPE FCC.** Three or more flat copper conductors placed edge-to-edge and separated and enclosed within an insulating assembly.
- **LISTING REQUIREMENTS.** Type FCC cable and associated fittings shall be listed.

Uses Permitted:

- **Branch Circuits.** Use of FCC system shall be permitted both for general purpose and appliance branch circuits and for individual branch circuits.
- **Branch Circuit Ratings. Voltage** – voltage between ungrounded conductors shall not exceed 300 volts. Voltage between ungrounded conductors and the grounded conductor shall not exceed 150 volts.

Uses Permitted:

- **Current** – genera l purpose and appliance branch circuit shall have ratings not exceeding 20 amperes . Individual branch circuit shall have rating not exceeding 30 amperes.
- **Floors.** Use of FCC system shall be permitted on hard, sound, smooth, continuous floor surfaces made of concrete, ceramics, or composition flooring, wood, and similar materials.

Uses Permitted:

- **Walls.** Use of FCC system shall be permitted on wall surfaces in surface metal raceways.
- **Damp Locations.** Use of FCC system in damp locations shall be permitted.
- **Heated Floors.** Materials used for floors heated in excess of 30°C shall be identified as suitable for use at these temperatures.

Uses Permitted:

- **System Height.** Any portion of an FCC system with a height above floor level exceeding 2.3 mm shall be tapered or feathered at the edges of the floor level.

BOXES AND FITTINGS:

Cable Connections and Insulating Ends:

- All type FCC cable connection shall use connectors identified for their use, installed such that electrical continuity, insulation, and sealing against dampness and liquid spillage are provided.
- All bare cable ends shall be insulated and sealed against dampness and liquid spillage using listed insulating ends.

BOXES AND FITTINGS:

Polarization of Connection:

- All receptacles and connections shall be constructed and installed so as to maintain proper polarization of the system

Shields:

- **Top Shield.** A metal top shield shall be installed over all floor-mounted type FCC cable, connectors, and insulating ends. The top shield shall completely cover all the cable runs, corners, connectors, and ends.
- **Bottom Shield.** A bottom shield shall be installed beneath all type FCC cable, connectors, and insulating ends.

BOXES AND FITTINGS:

Connection to other System

- Power feed, grounding connection, and shield system connection between the FCC system and other wiring systems shall be accomplished in a transition assembly identified for this use.

Metal-Shield Connectors

- Shall be connected to each other and to boxes, receptacle housings, self-contained devices, and transition assemblies using metal shield connectors

FLOOR COVERINGS:

- Floor mounted type FCC cable, cable connectors, and insulating ends shall be covered with carpet squares not larger than 1.0 m square. Carpet squares that are adhered to the floor shall attached with released type adhesives.

DEVICES:

Receptacles

- All receptacles, receptacle housings, and self contained devices used with the type FCC system shall be identified for this use and shall be connected to the type FCC cable and metal shields.
- Connection from any grounding conductor of the Type FCC cable shall be made to the shield system at each receptacle.

DEVICES:

Receptacles and Housing

- Receptacle housings and self-contained devices designed either for floor mounting or for in-wall or on-wall mounting shall be permitted for use with the FCC system.
- Receptacle housing and self contained devices shall incorporate means foe facilitating entry and termination of type FCC cable and for electrically connecting the housing or device with the metal shield.
- Receptacles and self contained shall comply with 4.6.1.4.

DEVICES:

Receptacles and Housing

- Power and communication outlets installed together in common housing shall be permitted in accordance with 8.0.5.24(A)(1)(d), Exception No.2.

SPLICES AND TAPS:

FCC System Alternation

- Alterations to FCC shall be permitted.
- New cable connectors shall be used at new connection points to make alterations.
- It shall be permitted to leave unused cable runs and associated cable connectors in placed and energized.
- All cable ends shall be covered with insulating ends.

SPLICES AND TAPS:

Grounding

- All metal shields, boxes, receptacle housing and self contained devices shall be electrically continuous to the equipment grounding conductor of the supplying branch circuit.

SHIELDS :

Materials and Dimensions

- All top and bottom shield shall be of designs and materials identified for their use.
- Top shield shall be metal.
- Both metallic and non-metallic materials shall be permitted for bottom shields.

Resistivity

- Metal shields have cross-sectional areas that provide for electrical resistivity of not more than that of conductor of the Type FCC cable used in the installation.

SHIELDS :

Corrosion Resistance

- Metal components of the system shall be either corrosion resistant, coated with corrosion-resistant materials, or insulated from contact with corrosive substances.

Insulation

- The insulating material of the cable shall be moisture resistant and flame retardant.
- All insulating materials in the FCC system shall be identified for their use.

MARKINGS:

a. **Cable Markings.** Type FCC cable shall be clearly and durably marked on both sides at intervals of not more than 610 mm with the information required by 3.10.3.17 (A) and the following additional information:

- Materials of conductors
- Maximum temperature rating
- Ampacity

b. **Conductor Identification.** Conductors shall be clearly and durably identified on both sides throughout their length as specified in 3.10.3.7.

INTEGRATED GAS SPACER CABLE: TYPE IGS

Definition:

- A factor assembly of one or more conductors, each individual insulated and enclosed in a loose fit, not metallic flexible conduit as an integrated gas spacer cable rated 0 through 600 volts.

INSTALLATION:

USES PERMITTED:

- Service entrance conductors
- Feeder or branch circuit conductors
- Service conductors, underground

INSTALLATION:

USES NOT PERMITTED:

- Shall not be used as interior wiring or be exposed in contact with buildings.

INSTALLATION:

- **Bending Radius.** Where the coilable conduit and cable are bent during shipment or installation, the radius of the curve of the inner edge of bends measured to the inside of the bend shall not be less than specified in the table.

Metric Designator	Trade size	Minimum radii (mm)
53 78 103	2 3 4	600 900 1150

INSTALLATION:

BENDS. A run of type IGS cable between pull boxes or terminations shall not contain more than the equivalent of four quarter bends 360 degrees total, including those bends located immediately at the pull box or terminations.

FITTINGS. Terminations and splices for type IGS shall be identified as a type that is suitable foe maintaining the gas pressure within the conduit. A valve and cap shall be provided for each length of the cable and conduit to check the gas pressure or to inject gas into the conduit.

CONSTUCTION AND SPECIFICATION:

- The conductors shall be solid aluminum rods, laid parallel, consisting of one to nineteen 12.7-mm diameter rods.
- The minimum conductor shall be 125 mm squared, and the maximum size shall be 2,375 mm^2.

Table 3.26.2.71

Size (mm squared)	Amperes	Size (kcmil)	amperes
125	119	1250	376
250	168	1500	412
400	206	1625	429
500	238	1750	445
600	266	1875	461
725	292	2000	476
580	344	1215	491
1000	336	2250	505
1125	357	2375	519

INSULATION:

- The insulation shall be dry kraft paper tapes and pressurized Sulfur HexaFlouride Gas SF6, both approved for electrical use.
- The nominal gas pressure shall be 138 kPa gauge.
- The thickness of the paper shall be as specified in table 3.26.3.9

Table 3.26.3.9

Size (mm squared)	Thickness (mm)
125-500 600-2375	1.02 1.52

CONDUIT:

- The conduit shall be medium density polythylene identified as suitable for use with natural gas rated pipe in the metric designator 53, 78, or 103.
- The percent fill dimension for the conduit shown in table 3.26.3.13

Table 3.26.3.13

Metric Designator	Trade size	Actual outside diameter	Actual inside diameter
53	2	60	49.46
78	3	89	73.30
103	4	114	94.23

MEDIUM VOLTAGE CABLE: TYPE MV

Type MV:

- A single or multiconductor solid dielectric insulated cable rated 2001 volts or higher.
- Type MV cables are typically specified as either an MV-90 or an MV-105, which signifies the maximum conductor temperature in degree Celsius (°C).

Uses Permitted:

- It can be use for power systems rated up to and including 35KV.
- In wet or dry locations
- Cable trays where type MV cable has an overall metallic sheath or armor.
- Direct buried in accordance with 3.0.2.20
- In messenger supported wiring in accordance with part 3.96.2
- Exposed runs in accordance with 3.02.7 Type MV cable that has an overall metallic sheath or armor.

Uses not permitted:

- Type MV cable shall not be used where exposed to direct sunlight, unless identified for that purpose.

Installation:

- Type MV cable shall be installed, terminated, and tested by qualified persons.

Support:

- Type MV cable terminated in equipment or installed in pull boxes or vaults shall be supported by metallic or nonmetallic supports suitable to withstand its weight.
- Not exceeding 1500 mm from terminations or a maximum of 1800 mm between supports.

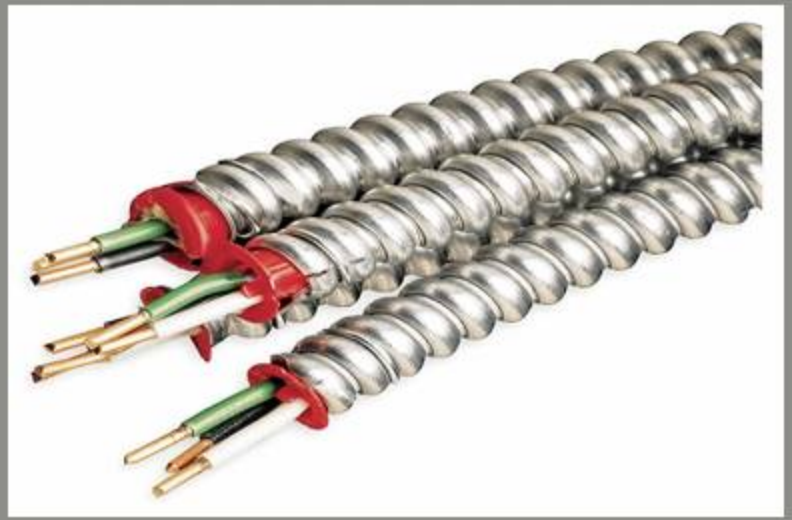
Ampacity of Type MV cable:

- Shall be determined in accordance with 3.10.2.51. When installed in a cable tray shall be determined in accordance with 3.92.2.71(B).

Construction Specification:

- Type MV cable shall have copper, aluminum, or copper-clad conductors and shall comply with table 3.10.3.1(C) and table 3.10.3.1 (D) or table 3.10.3.1 (E).

METAL CLAD CABLE : TYPE MC



METAL CLAD CABLE : TYPE MC

- It is factory assembled of one or more conductors.
- It is a cable in which the conductors are enclosed in a corrugated metal sheath or interlocking metal tape, insulated.
- The armor is not an equipment grounding means.

Installation:

Uses permitted:

- For services, feeders, and branch circuits.
- For power, lighting, control, and signal circuits.
- Indoors or outdoors.
- Exposed or concealed.
- To be direct buried where identified for such use
- In cable tray where identified for such use.
- In any raceway
- As aerial cable on a messenger.

Raceway and Messenger:

Raceway

Aerial cable on a messenger

- In hazardous (classified) locations where specifically permitted by other articles in this *Code*
- In dry locations and embedded in plaster finish on brick or other masonry except in damp or wet locations.

In wet locations where a corrosion-resistant jacket is provided over the metallic covering and any of the following conditions are met:

1. The metallic covering is impervious to moisture
2. A jacket resistant to moisture is provided under the metal covering
3. The insulated conductors under the metallic covering are listed for use in wet locations
4. Where single-conductor cables are used, all phase conductors and, where used, the grounded conductor shall be grouped together to minimize induced voltage on the sheath.

SPECIFIC USES:

- TYPE MC cable shall be permitted to be installed in compliance with Parts 7.25.2 and 7.25.3 and 7.70.5.4 as applicable and in accordance with 3.30.2.1(B)(1) through (B)(4).
  1. Cable Tray. Type MC cable installed in cable tray shall comply with 3.92.2.1, 3.92.2.3, 3.92.2.18, 3.92.2.11 , 3.92.2.13 , 3.92.2.21, 3.92.2.37, 3.92.2.47, 3.92.2.51(C) and 3.92.2.71.

SPECIFIC USES:

2. Direct Buried- shall comply with 3.0.1.5 or 3.0.2.20 as appropriate
3. Installed as Service-Entrance Cable- In accordance with 2.30.4.4
4. Installed Outside of building or structures or as Aerial Cable. Type MC cable installed outside of buildings or structures or as aerial cable shall comply with 2.25.0.10 and 3.96.2.3

Uses Not Permitted:

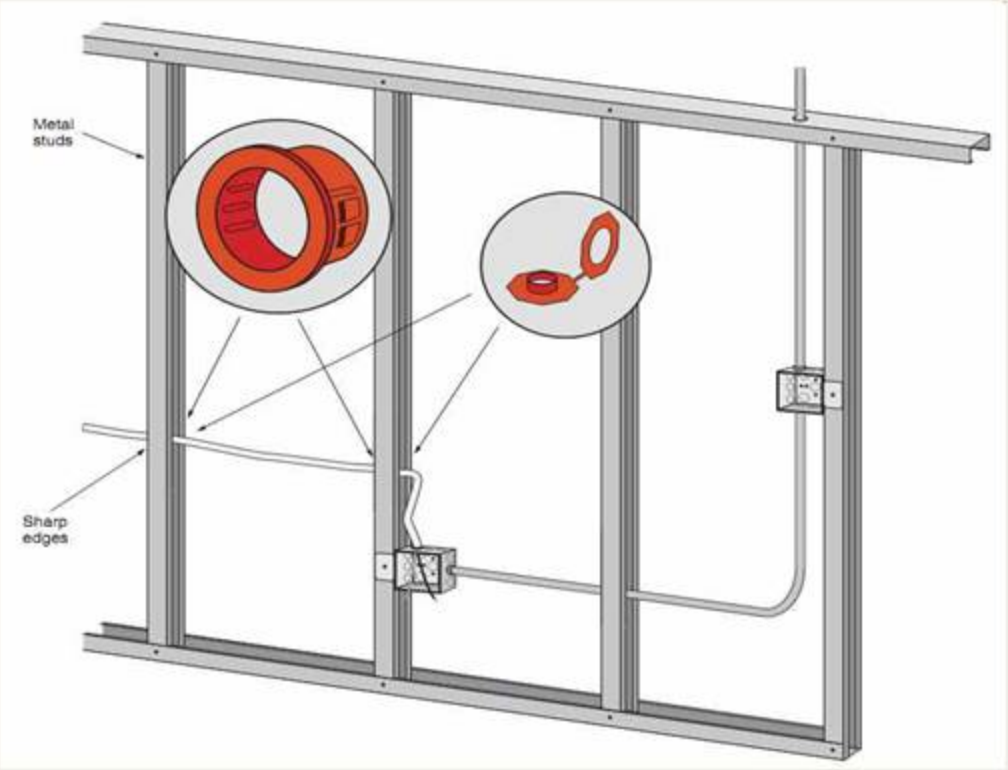
Type MC cable shall not be used under either of the following conditions.

- Where subject to physical damage
- Where exposed to any of the destructive corrosive conditions in (a) or (b), unless the metallic sheath or armor is resistant to the conditions or is protected by material resistant to the conditions:
  a) *Direct buried in the earth or embedded in concrete unless identified for direct burial.*
  b) *Exposed to cinder fills, strong chloride, caustic alkalis, or vapors of chlorine or hydrochloric acids.*

Uses Not Permitted:

- Exposed work : Exposed runs of cable, except as provided in 3.0.1.11(A).
- Shall closely follow the surface of the building finish or of running boards and also on the underside of joists and not subjected to physical damage.

Through or Parallel to Framing Members. Type MC cable shall be protected in accordance with 3.0.1.4(C) and (D).



(A) Smooth Sheath

1. Ten times the external diameter of the metallic for cable not more than 19 mm in external diameter.
2. Twelve times the external diameter of the metallic sheath for cable more than 19 mm but not more than 38mm in external diameter
3. Fifteen times the external diameter of the metallic sheath for cable more than 38mm in external diameter.

(B) Interlocked-Type Armor or Corrugated Sheath – Seven times the external diameter of the metallic sheath.

(C) **Shielded Conductors** – Twelve times the overall diameter of one of the individual conductors or seven times the overall diameter of the multiconductor cable.

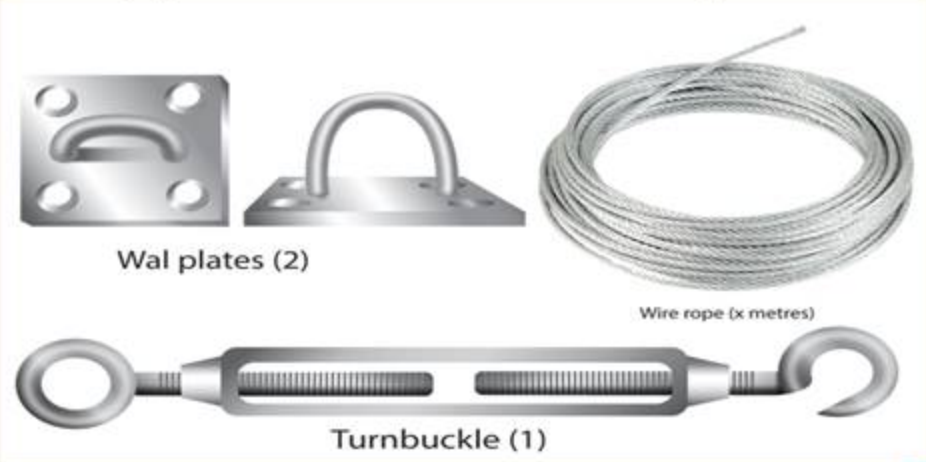
SECURING AND SUPPORTING

(a) **General.** Type MC cable shall be supported and secured by staples, cable ties listed and identified for securement and support; straps, hangers, or similar fittings; or other approved means designed and installed so as not to damage cable.

(b) **Securing.** Unless otherwise provided:

- *Cable shall be secured at intervals not exceeding 1800 mm.*
- *Cables containing four or fewer conductors sized no larger than 2.6 mm in dia.*
- *Shall be secured within 300 mm of every box, cabinet, fitting, or other cable termination.*
- *In vertical installations, listed cables with ungrounded conductors 125 mm^2 and larger shall be permitted to be secured at intervals not exceeding 3000 mm.*

(c) **Supporting.** Unless or otherwise provided, cable shall be supported not exceeding 1,800 mm.



Securing and supporting cables

(d) **Unsupported Cables.** Shall be permitted to be unsupported and unsecured but complying:

1. Is fished between access points through concealed spaces in finished buildings or structures and supporting is impractical.
2. Is not more than 1800mm in length from the last point of cable support to the point of connection to luminaires or other electrical equipment and the cable.
3. and point of connection are within an accessible ceiling.

(d) **Unsupported Cables.** Shall be permitted to be unsupported and unsecured but complying:

4. Is Type MC of the interlocked armor type in lengths not exceeding 900mm from the last point where it is securely fastened and is used to connect equipment where flexibility is necessary

Single Conductors. Where single-conductor cables with a nonferrous armor or sheath are used, the installation shall comply with 3.0.1.20.

Ampacity. Shall be determined in accordance with 3.10.2.6 or 3.10.2.51 for 1.6mm in dia. And larger conductor and in accordance with table 4.2.1.5 for 0.75 mm^2(1mm dia.) and 1.25 mm^2 (1.2mm dia.) conductors. The installation shall not exceed the temperature ratings of terminations and equipment.

(a.)**Type MC cable installed in Cable Tray.** The ampacities of the Cable shall be determined in accordance with 3.92.2.71.

(b.) Single Type MC Conductors Grouped together:

- Where single Type MC conductors are grouped together in a triangle or square configuration and installed in a messenger or exposed with a maintained free airspace on not less than 2.15 times one conductor diameter of the largest conductor contained within.
- The allowable ampacities shall not exceed in the following tables:

1. *Table 3.10.2.6(B)(20) for conductors rated 0 to 2000 volts.*
2. *Table 3.10.2. 5(C)(67) and table 3.10.2. 51(c)(68) for conductors rated over 2000 volts*

CONSTRUCTION SPECIFICATIONS:

Conductors.

- *Shall be of copper, aluminum, copper-clad aluminum, nickel or nickel-coated copper, solid or stranded.*
- *The minimum conductor size shall be 0.75 mm^2 copper, nickel or nickel coated, or 3. 5 mm^2 aluminum or copper-clad aluminum.*

Equipment Grounding Conductor(EGC).

- *When the cable is used to provide an EGC, it shall comply with 2. 50.6.9 and 2. 50.6.13*

Insulation.

- *Insulated conductors shall comply with 3.30.3.9(a) or (b)*

(a) **1,000 volts or less.** Insulated conductors in sizes 18 AWG and 1.25 mm^2. Shall be of a type listed in Table 4.2.1.3 with a maximum operating temp. not less than 90 Celsius and as permitted by 7.25.2.9. Larger than 1.25mm^2 shall be in Table 3.10.3.1

(b) **Over 1,000 volts.** Insulated conductors shall be of a type listed in table 3.10.3.1(B) and table 3.10.3.1(C).

MINERAL-INSULATED, METAL-SHEATHED CABLE : TYPE MI

- Mineral insulated cable is a type of bendable metal cable used in temperature sensor manufacture.
- It is also known as Mineral insulated metal sheath or **MIMS** for short.
- Mineral insulated cable is made from a seamless metal tube, tightly packed with copper or alloy sheath.
- It is suitable for the most demanding applications that include instrumentation and power in hazardous locations, outdoor use for services, feeders and branch circuits, nuclear reactors, and extremely high ambient temperatures.

Uses Permitted. Type MI cable shall be permitted as follows:

1. For services, feeders, and branch circuits
2. For power, lighting, control, and signal circuits
3. In dry, wet, or continuously moist locations
4. Indoors or outdoors
5. Where exposed or concealed
6. Where embedded in plaster, concrete, fill, or other masonry, whether above or below grade

7. In hazardous (classified) locations where specifically permitted by other articles in this code.
8. Where exposed to oil and gasoline
9. Where exposed to corrosive conditions not deteriorating to its sheath
10. In underground runs where suitably protected against physical damage and corrosive conditions.
11. In or attached to cable trays

Uses Not Permitted

Type MI cable shall not be use on the following conditions or in the following locations:

1. In underground runs unless protected from physical damage
2. Where exposed to conditions that are destructive and corrosive to the metallic sheath , unless additional protection is provided.

Bending Radius. The radius of the inner edge of any bend shall not be less than required as follows:

1. Five times the external diameter of the metallic sheath for cable not more than 19 mm in external diameter.
2. Ten times the external diameter of the metallic sheath for cable greater than 19 mm but not more than 25 mm in external diameter.

Securing and supporting. Type MI cable shall be supported and secured by staples, straps, hangers, or similar fittings, designed and installed so as not to damage the cable, at intervals not exceeding 1800 mm.

(A) **Horizontal Runs Through Hole and Notches.** In other than vertical runs, cables installed in accordance with 3.0.1.4 shall be considered supported and secured where such support does not exceed 1800 mm intervals.

(B) **Unsupported Cable.** Shall be permitted to be unsupported where the cable is fished between access points through concealed spaces in finished buildings or structures and supporting is impracticable.

(C) **Cable Trays.** Shall comply with 3.92.2.21(A)
Single Conductors. Where single-conductor cables are used, all phase conductors and, where used, the neutral conductor shall be grouped together to minimize induced voltage on the sheath.

BOXES AND FITTINGS

A. **Fittings.** Fittings used for connecting Type MI cable to boxes, cabinets, or other equipment shall be identified for such use.

B. **Terminal Seals.** Where type MI cable terminates an end seal fitting shall be installed immediately after stripping to prevent the entrance of moisture into the insulation. The conductors extending beyond the sheath shall be individually provided with an insulating material.

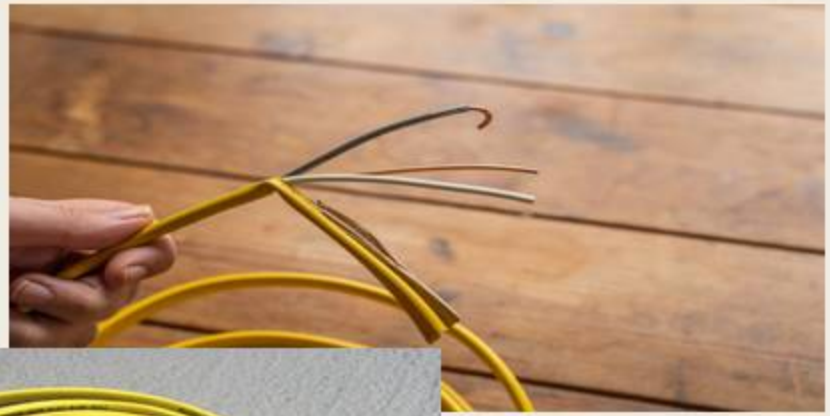
- **Ampacity.** Shall be determined in accordance with 3.10.2.6
- The conductor temperature shall not exceed temperature rating of the end seal fitting. And the installation shall not exceed the temp. ratings of terminations and equipment.
- **Cable Tray.** Shall be in accordance with 3.92.2.71(A)
- **Single Type MI Grouped Together.** Where single Type MI conductors are grouped together in a triangle or square configuration and installed in a messenger or exposed with a maintained free airspace on not less than 2.15 times one conductor diameter of the largest conductor contained within.

CONSTRUCTION SPECIFICATIONS:

- **Conductors.** Type MI cable conductors shall be of solid copper, nickel, or nickel-coated copper with a resistance corresponding to standard AWG and kcmil sizes. (**kcmil** = 0.5067 mm^2)
- **Equipment Grounding Conductor.** When outer sheath is made of copper, it shall provide an adequate path to serve as equipment grounding conductor.
- **Insulation.** Conductor Insulation shall be a highly compressed refractory mineral that provides proper spacing for all conductors.

NONMETALLIC-SHEATHED CABLE: TYPES NM,NMC, AND NMS

Definitions. A factory assembly of two or more insulated conductors enclosed within an overall nonmetallic jacket.



- **Type NM.** Insulated conductors enclosed within an overall nonmetallic jacket.
- **Type NMC.** Insulated conductors enclosed within an overall, corrosion resistant, nonmetallic jacket.
- **Type NMS.** Insulated power or control conductors with signaling, data, and communications conductors within an overall nonmetallic jacket.

Uses permitted: This cable shall be used in the following, except as prohibited in 3.34.2.3:

- One and two family dwellings and their attached or detached garages, and their storage buildings.
- Multi-family dwellings permitted to be of Types III, IV, and V construction.
- Other structures permitted to be of types III, IV, and construction.
- Cables shall be concealed within wall, floors, or ceilings that provide a thermal barrier of material that has at least a 15-minute finish rating as identified in listings of fire-rated assemblies.

- Cable trays in structures permitted to be Types III, IV, or V where the cables are identified for the use.
- Types I and II construction where installed within raceways permitted to be installed in Types I and II construction.

A. Type NM. Permitted as follows:

1. For both exposed and concealed work in normally dry location except as prohibited in 3.34.2.1(3).
2. To be installed or fished in air voids in masonry block or tile walls.

B. Type NMC. Shall be permitted as follows:

1. For both exposed and concealed work in dry, most, damp, or corrosive locations, except as prohibited by 3.34.2.1(3)
2. In outside and inside walls of masonry, concrete, or tile
3. In a shallow chase in masonry, concrete, or adobe protected against nails or screws by a steel plate at least 1.59 mm thick and covered with plaster, adobe, or similar finish

Type NMS. Shall be permitted as follows:

1. For both exposed and concealed work in normally dry locations except as prohibited by 3.34.2.1(3).
2. To be installed or fished in air voids in masonry block or tile walls

Uses Not Permitted.

A. Type NM, NMC, and NMS.

1. In any dwelling or structure not specifically permitted in 3.34.2.1(1), (2),(3) and (5).
2. Exposed within a dropped or suspended ceiling cavity in other than one and two family multifamily dwellings.
3. As service entrance cable.

4. In commercial garages having hazardous(classified) locations as defined in 5.11.1.3
5. In theaters and similar locations, except where permitted in 5.18.1.4(B)
6. In motion picture studios
7. In storage battery rooms
8. In hoistways or on elevators or escalators
9. Embedded in poured cement, concrete, or aggregate
10. In hazardous (classified) locations, except where specifically permitted by other articles in this *Code*.

(B) **Type NM and NMS.** Shall not be permitted as follows:

1. Where exposed to corrosive fumes or vapors
2. Where embedded in masonry, concrete, adobe, fill or plaster
3. In a shallow chase in masonry, concrete, or adobe and covered with plaster, adobe, or similar finish
4. In wet or damp locations

Exposed Work

- In exposed work, except as provided in 3.0.1.11(A), cable shall be installed as specified in 3.34.2.6(A) through (C)

A. **To follow surface.** Cable shall closely follow the surface of the building finish or of running boards.

B. **Protection from Physical damage.** Cable shall be protected from physical damage where necessary by rigid metal conduit, intermediate metal conduit, electrical tubing, Schedule 80 PVC conduit or other means.

C. In Unfinished Basements and Crawl Spaces. Where Cable is run at angles with joists in unfinished basements and crawl spaces, it shall be permissible to secure cables not smaller than two 14mm^2 or three 8mm^2 conductors directly to the lower edges of the joists.

Through or Parallel to Framing Member. Type NM, NMC, or NMS cable shall be protected in accordance with 3.0.1.4 where installed through or framing members.

In Accessible Attics. The installation of cable in accessible attics or roofs spaces shall comply with 3.20.2.14

Bending Radius. The radius of the curve of the inner edge of any bend during or after installation shall not be less than five times the diameter of the cable.

Securing and Supporting. Shall be supported and secured by staples, cable ties listed and identified for securement and support; or straps, hangers or similar fittings designed and installed so as not to damage the cable. At intervals not exceeding 1400mm and within 300mm of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets or fittings.

Unsupported Cables. Nonmetallic-sheathed cable shall be permitted to be unsupported where the cable:

1. Is fished between access points through concealed space in finished buildings or structures and supporting is impracticable.
2. Is not more than 1400 mm from the last point of cable support to the point of connection to a luminaire or other piece of electrical equipment and the cable and point of connection are within an accessible ceiling.

Wiring devices Without a Separate Outlet Box and incorporating and integral cable clamp shall be permitted where the cable is secured in place at Intervals not exceeding 1400 mm and within 300mm from the wiring device wall opening,

Boxes and Fittings.

Devices of Insulating Material. Self contained switches, self contained receptacles, and nonmetallic-cable interconnector devices of insulating material that are listed shall be permitted to be used without boxes in exposed cable wiring and for repair wiring in buildings which cables are concealed.

Devices with Integral Enclosures. Wiring devices with integral enclosures identified for such use shall be permitted as provided by 3.0.1.15(E).

Ampacity. Shall be determined in accordance with 3.10.2.6. The allowable ampacity shall not exceed that of a 60 Celsius rated conductor. 90 Celsius can be used for ampacity adjustment and correction calculations, provided that the final calculated does not exceed 60 Celsius rated conductor.

Where more than two NM cables containing two or more current carrying conductors are installed, without maintaining spacing between cables shall be adjusted with accordance with Table 3.10.2.6(B)(3)(a) and the provisions of 3.10.2.6(A)(2), No Exceptions.

Construction Specification

- **Construction.** The outer cable sheath of nonmetallic-sheathed cable shall be a nonmetallic material.
- **Conductors.** The 600-volt insulated conductors shall be sizes 2.0mm^2(1.6mm dia) through 30 mm^2 copper conductors or sizes 2.0 mm^2 through 30mm^2 aluminum or copper-clad aluminum conductors. The communications conductors shall comply with Part 8.0.5.
- **Equip Grounding Conductor.** In addition to the insulated conductors, the cable shall have an insulated covered, or bare equipment grounding conductor.

Insulation. The insulated power conductor shall be one of the types listed in Table 3.10.3.1(A) that are suitable for branch circuit wiring or one that is identified for use in these cables. Conductor insulation shall be rated at 90 °Celsius.

(A) **Type NM**: The overall covering shall be flame retardant and moisture resistant.

(B) **Type NMC**: The overall covering shall be flame retardant and moisture resistant, fungus resistant, and corrosion resistant.

(C) **Type NMS**: The overall covering shall be flame retardant and moisture resistant. The sheath shall be applied so as to separate the power conductors from the communications conductors.

POWER AND CONTROL TRAY CABLE: TYPE TC

- A factory assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors, under a nonmetallic jacket.

Uses permitted

- For power, lighting, control, and signal circuits.
- In cable trays, including those with mechanically discontinuous segments up to 300 mm.
- In raceway.
- In outdoor locations supported by a messenger wire.7.
- For class 1 circuits as permitted in parts 7.25.2 and 7.25.3.
- For non-power limited fire alarm circuits if conductors comply with the requirements of 7.60.2.9.
- Between a cable tray and the utilization equipment or devices provided all of the following apply:

- In one and two family dwelling units type TC cable containing both power and control conductors that is identified.
- Where installed in wet locations, type TC cable shall also be resistant to moisture and corrosive agents.
- Direct buried, where identified for such use.
- Exception: where use to connect a generator and associated equipment having terminals rated 75 degrees celsius or higher, the cable shall not be limited in ampacity by 3.34.2.71 or 3.40.2.71

USES NOT PERMITTED

- Installed where it will be exposed to physical damage
- Installed outside a raceways or cable tray system except as permitted in 3.36.2.1(4) and 3.36.2.1(7).
- Used when exposed to direct rays of the sun unless identified as sunlight resistant.

Bending radius. For type TC cable without metal shielding, the minimum bending radius shall be as follows:

1. 4 times the overall diameters for cables 25 mm or less in diameter.
2. 5 times the overall diameter for cables larger than 25 mm but no more than 50 mm in diameter.
3. 6 times the overall diameter for cables larger than 50 mm in diameter.
4. Type TC cables with metallic shielding shall have a minimum bending radius not less than 12 times the cable overall diameter.

CONSTRUCTION SPECIFICATIONS

Construction

- A metallic sheath or armor as defined in 3.30.3.17 shall not be permitted either under or over the non metallic jacket.
- Metallic shield shall be permitted over groups of conductors, under the outer jacket or both.

Conductors

- The insulated conductors of type TC cables shall be in size of 0.75 m sq.(1.0 mm in dia) to 500 mm sq.
- Copper, nickel or nickel coated copper and sizes 3.5mm sq.(2.0 mm in dia.)
- Through 500 mm sq. Aluminum or copper clad aluminum.
- Insulated conductors of sizes 2.0 mm sq.(1.6mm in dia) and larger copper, nickel or nickel coated copper size and sizes 3.5mm sq.(2.0 mm in dia) through 500 mm sq. Aluminum or copper clad aluminum shall be one of the types.

1. Fire alarm systems. Where used for fire alarm system conductors shall also be accordance with 7.60.2.9
2. Thermocouple circuits. Conductors in type tc cable used for thermocouple circuit in accordance with part 7.25.3 shall also be permitted to be any of the materials used for thermocouple extension wire.
3. Class 1 circuit breakers. Insulated conductors of 0.75mm sq.(1.0mm in dia.)Copper shall be in accordance with 7.25.2.9.

- **Jacket**. The outer jacket shall be a retardant, non metallic material.
- **Marking**. There shall be no voltage marking on a type TC cable employing thermocouple extension wire.

SERVICE ENTRANCE CABLE: TYPES SE AND USE

Service entrance cable. A single conductor or multi conductor assembly provided with or without an overall covering, primarily used of services, and of the following types:

Type SE. Service entrance cables having a flame retardant, moisture resistant covering.

Type USE. Service entrance cable identified for underground use, having a moisture resistant covering but not required to have a flame retardant covering.

Uses permitted

A. **Service-entrance cable conductors**. Shall be installed accordingly

B. **Branch circuit or feeders**.

1. **Grounded conductor insulated**. Type se service entrance cables shall be permitted in wiring systems where all of the circuit conductors of the cable are thermoset or thermoplastic type.
2. **Use of uninsulated conductor**. Type se service entrance cables shall be permitted for use where the insulated conductors are used for circuit wiring and the uninsulated conductor is used for equipment grounding purposes.
3. **Temperature limitations**. Type se service entrance cable used to supply appliances shall not be subjected to conductor temperatures in excess of the temperature specified for the type of insulation involved.
4. **Interior installations**. Type se cable used for interior wiring shall comply with installation requirements.

Uses not permitted:

- **Service entrance cable.** Service entrance cable shall not be used under the following conditions.

1. Where subject to physical damage unless protected in accordance with 2.30.11(b).
2. Underground with or without a raceway.
3. For exterior branch circuits and feeders wiring unless the installation complies with the provisions of part 2.25.1 and is supported in accordance with 3.34.2.21 or it is used as messenger supported wiring as permitted in part 3.96.2

CONSTRUCTION SPECIFICATIONS

- **Construction**. Cabled, single conductor type use construction recognized for underground use shall be permitted to have a bare copper conductor cabled with the assembly. Type use single parallel or cabled conductor assemblies recognized for underground use shall be permitted to have a bare copper concentric conductor applied. These construction shall not require an outer overall covering.
- Type se or use cable containing two or more conductors shall be permitted to have one conductor uninsulated.
- **Marking**. Service entrance cable shall be marked as required in 3.10.3.17.Cable with the neutral conductor smaller than the ungrounded conductors shall be so marked.

UNDERGROUND FEEDER AND BRANCH CIRCUIT CABLE:TYPE UF

Definition:

- Underground feeder and branch circuit cable, type UF.
- A factory assembly of one or more insulated conductors with an integral or an overall covering of nonmetallic material suitable for direct burial in the earth.

Uses not permitted

1. For use underground ,including direct burial in the earth for underground requirements, see 3.0.1.5.
2. Installed at single conductor of the feeder grounded conductor or branch circuit including the grounded conductor and equipment grounding conductor f any shall be installed in accordance with 3.0.1.3.
3. For wiring in wet, dry or corrosive locations under the recognized wiring methods of the code.

4. Installed as nonmetallic sheathed cable. Where so installed, the installation and conductor requirements shall comply with parts 3.34.3 and shall be of the multi conductor type.
5. For solar photovoltaic system in accordance with 6.90.4.1
6. As single conductor cables as the non heating leads for heating cables as provided in 4.24.5.10
7. Supported by cable trays, Type UF cable supported by cable trays shall be of the multi conductor type.

- Uses not permitted

1. As service entrance cable
2. In commercial garages
3. In theaters and similar locations
4. In motion picture studios
5. In storage battery rooms
6. In hoistways or on elevators or escalators.

7. In hazardous locations except as specifically permitted by other articles in this code.
8. Embedded in poured cement, concrete, or aggregate, except where embedded in plaster as non heating leads where permitted in 4.24.5.10
9. Where exposed to direct rays of the sun, unless identified as sunlight resistant
10. Where subject to physical damage
11. As overhead cable except where installed as messenger supported wiring in accordance with part 3.96.2

- **Bending radius.** Bends in type UF cable shall be so made that the cable is not damaged. The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable.
- **Ampacity.** The ampacity of Type UF cable shall be that of 60 centigrade conductors in accordance with 3.10.2.

CONSTRUCTION SPECIFICATIONS

- **Conductors**. The conductors shall be sizes 2.0mm sq (1.6mm dia.) Copper 3.5mm sq.(2.0mm dia) aluminum or copper clad aluminum through 100mm sq.
- **Equipment grounding conductor**. In addition to the insulated conductors the cable shall be permitted to have an insulated or bare equipment grounding conductor.
- **Insulation**. The conductors of type uf shall be one of the moisture resistant types listed in table 3.10.3.1(a) that is suitable for branch circuit wiring or one that is identified for such use. Where installed as a substitute wiring method for nm cable the conductor insulation shall be rated 90 centigrade.
- **Sheath**. The overall covering shall be flame retardant, moisture, fungus and corrosion resistant and suitable for direct burial in the earth.

INTERMEDIATE METAL CONDUIT:TYPE IMC

INTERMEDIATE METAL CONDUIT:TYPE IMC

- A steel threadable raceways of circular cross sections designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings.

■ Uses permitted

A. **All atmospheric conditions and occupancies**. Use of IMC shall be permitted under all atmospheric conditions and occupancies.

B. **Corrosion environments**. IMC elbows couplings and fittings shall be permitted to be installed in concrete in direct contact with the earth or in area subject to severe corrosive influences where protected by corrosion protection approved for the condition.

C. **Wet locations**. All support bolts straps, screws, and so forth shall be of corrosion resistant materials or protected against corrosion by corrosion resistant material.

D. **Cinder fill**. Imc shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of non-cinder concrete not less than 50mm thick where the conduit is not less than 450mm under the fill or where protected by corrosion protection approved for the condition.

- **Dissimilar metals.** Where practicable dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Aluminum fittings and enclosures shall be permitted to be uses with galvanized steel IMC where not subject to severe corrosive influences. Stainless steel IMC shall only be used with stainless steel fittings and approved accessories, outlet boxes and enclosures.

- Size
  A. **Minimum.** *IMC* smaller than metric designator 16 (traded size one half)shall not be used
  B. **Maximum.** *IMC* larger than metric designator 103 (trade size 4)shall not be used.
- **Number of conductors.** The number of conductors shall not exceed that permitted by the percentage fill specified.

- **Bends-how made.** Bend of IMC shall be so made that the conduit will not be damaged and the internal diameter of the conduit will not be effectively reduced. The radius of the curve of any field bend to the centerline of the conduit shall not be less than.
- **Bends-number in one run.** There shall not be more than the equivalent of four quarter bends between pull points for example conduit bodies and boxes.

- **Reaming and threading.** All cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with a taper of 1 in 16(3/4 in taper per foot shall be used.
- **Securing and supporting.** IMC shall be installed as a complete system in accordance with 3.0.1.18 and shall be securely fastened in place and supported in accordance with 3.42.2.21(a)and (b).

SECURELY FASTENED.IMC SHALL BE SECURED IN ACCORDANCE WITH ONE OF THE FOLLOWING;

1. LMC shall be securely fastened within 900mm of each outlet box, junction box, device box, cabinet, conduit body or other conduit termination.
2. Where structural members do not readily permit fastening within 900mm,fastening shall be permitted to be increased to a distance of 1 500mm.
3. Where approved conduit shall not be required to be securely fastened within 900mm of the service head for above the roof termination of a mast.

SUPPORTS. IMC SHALL BE SUPPORTED IN ACCORDANCE WITH ONE OF THE FOLLOWING;

1. Conduit shall be supported at intervals not exceeding to 3000mm
2. The distance between support for straight runs of conduit shall be. Provided the conduit is made up with threaded couplings and such supports prevent transmissions of stresses to termination where conduit is deflected between supports.

SUPPORTS. IMC SHALL BE SUPPORTED IN ACCORDANCE WITH ONE OF THE FOLLOWING;

3. Exposed vertical risers from industrial machinery or fixed equipment shall be permitted to be supported at intervals not exceeding 6000 mm if the conduit is made up with threaded couplings, the conduit is supported and securely fastened at the top and bottom of the riser and no other means of intermediate support is readily available.

4. Horizontal runs of IMC supported by openings through framing members at intervals not exceeding 300 mm and securely fastened within 900 mm of termination points shall be permitted

- **Bushings.** Where a conduit enters a box fittings or other enclosure a bushing shall be provided to protect the wires from abstraction unless the box, fitting or enclosure is designed to provide such protection.
- **Splices and taps.** Splices and tops shall be made in accordance with 3.0.1.15.
- **Grounding.** IMC shall be permitted as an equipment grounding conductor.
- **Construction.** IMC shall be made of one the following;
    1. *Steel with protective coatings*
    2. *Stainless steel*

CONSTRUCTION SPECIFICATION

- **Marking.** Each length shall be clearly and durably marked at least every 1500 mm with the letters IMC. Each length shall be marked as required in 1.10.1.21.
- **Standard lengths.** The standard length of IMC shall be 3000 mm including an attached coupling and each other end shall be threaded. Longer or shorter length with or without coupling and threaded or unthreaded shall be permitted.

RIGID METAL CONDUIT: TYPE RMC
FLEXIBLE METAL CONDUIT: TYPE FMC
LIQUIDTIGHT FLEXIBLE METAL CONDUIT: TYPE FMC

RIGID METAL CONDUIT: TYPE RMC

RIGID METAL CONDUIT (RMC). Circular cross section designed for the physical protection and routing of conductors and cables

Uses Permitted

- ❑ Atmospheric Conditions and Occupancies
- ❑ Corrosive Environments
- ❑ Cinder Fill
- ❑ Wet Locations

Size

- **Minimum.** RMC smaller that metric designator 16 (trade size ½) shall not be used
- **Maximum.** RMC larger than metric designator 155(trade size 6) shall not be used

3.44.2.21 (B)(2) Supports for RMC

CONDUIT SIZE		MAXIMUM DISTANCE BETWEEN RMC SUPPORTS
Metric Designator	Trade Size	(mm)
16-21	1/2-3/4	3000
27	1	3600
35-41	1 1/4- 1 1/2	4200
53-63	2 - 2 1/2	4800
78 and larger	3 and larger	6000

- **Bends-How Made.** Shall be made so that the tubing shall not be damaged as well as the internal diameter not be effectively reduced.
- **Bends-Number in One Run.** Shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points.
- **Reaming.** All cut ends shall be reamed
- **Grounding.** RMC shall be permitted as an equipment grounding conductor
- **Marking.** RMC shall be clearly and durably marked at least every 3000mm

FLEXIBLE METAL CONDUIT: TYPE FMC

- **Flexible Metal Conduit (FMC)** - circular cross section made of helically wound, formed, interlocked metal strip

- **Uses Permitted** - FMC, shall be permitted to be used in exposed and concealed locations

Uses not Permitted

- ❑ Wet Locations
- ❑ Hoistways
- ❑ Storage Battery Rooms
- ❑ Hazardous Locations
- ❑ Exposed to Materials
- ❑ Underground or Embedded
- ❑ Subject to Physical Damage

Size

- **Minimum.** FMC smaller than metric designator 16 (trade size 1/2) shall not be used.
- **Maximum.** FMC larger than metric designator 103 (trade size 3/8) shall not be used.
- **Grounding.** Shall be permitted as an equipment grounding conductor

Size [mm² (mm dia.)]	Types RFH-2, SF-2		Types TF, XHHW, TW		Types TFN, THHN, THWN		Types FEP, FEBP, PF, PGF	
	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit	Fittings Inside Conduit	Fittings Outside Conduit
.75(1.0)	2	3	3	5	5	8	5	8
1.25(1.2)	1	2	3	4	4	6	4	6
2.0(1.6)	1	2	2	3	3	4	3	4
3.5(2.0)	-	-	1	2	2	3	2	3
5.5(2.6)	-	-	1	1	1	1	1	2

- **Bends-How Made.** Shall be made so that the tubing shall not be damaged as well as the internal diameter not be effectively reduced.
- **Bends-Number in One Run.** Shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points.
- **Securing and Supporting.** shall be securely fastened in place and supported in accordingly.
- **Bushings.** bushing or adapter shall be provided to protect the wire from abrasions
- **Grounding.** a separate grounding conductor shall be installed in the raceway

- **Couplings and Connectors.** Couplings and connectors used with FMC shall be made up tight.
- **Grounding.** FMC shall be permitted as an equipment grounding conductor
- **Marking.** FMC shall be clearly and durably marked at least every 3000mm
- **Trimming.** Cut ends hall be trimmed.

LIQUIDTIGHT FLEXIBLE METAL CONDUIT: TYPE LFMC

- **LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)** - circular cross section with liquidtight, nonmetallic, sunlight-resistant jacket or an inner flexible metal core with coupling connectors

Uses Permitted

- requires flexibility or protection in installation
- Hazardous location (Chap 5)
- Direct Burial
- Hazardous Locations

Uses Not Permitted

- Subject to physical damage
- Combination of ambient and conductor temperature produces an operating temperature excess approved by material

- **Bends-How Made.** shall be made so that the tubing shall not be damaged as well as the internal diameter not be effectively reduced.
- **Bends-Number in One Run.** Shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points
- **Trimming.** All cut ends shall be trimmed inside and outside
- **Securing and Supporting.** shall be securely fastened within 300mm in place and supported intervals not exceeding 1400 mm.

- **Couplings and Connectors.** only fittings listed for LFMC shall be used. Angle connectors shall not be concealed.
- **Splices and Taps.** shall be made in accordance with 3.0.1.15
- **Grounding.** flexibility is neccessary to minimize the transmission of vibration.

RIGID POLYVINYL CHLORIDE CONDUIT: TYPE PVC

Uses Permitted

- ❑ Concealed- (Walls, Influences, & Ceilings)
- ❑ Corrosive Influences
- ❑ Cinders
- ❑ Wet Locations
- ❑ Dry and Damp Locations
- ❑ Exposed
- ❑ Underground Installations
- ❑ Support of Conduit
- ❑ Installation Temperature Limitation

Uses Not Permitted

- ❑ Hazardous Location
- ❑ Support of Luminaires
- ❑ Physical Damage
- ❑ Ambient Temperatures
- ❑ Theaters and Similar Locations

Size

- **Minimum.** FMC smaller than metric designator 16 (trade size 1/2) shall not be used.
- **Maximum.** FMC larger than metric designator 155 (trade size 6) shall not be used.
- **Grounding.** Shall be permitted as an equipment grounding conductor

- **Bends-How Made.** shall be made so that the tubing shall not be damaged as well as the internal diameter not be effectively reduced.
- **Trimming.** All cut ends shall be trimmed inside and outside
- **Securing and Supporting.** shall be securely fastened in place and supported in accordingly.
- **Bushings.** bushing or adapter shall be provided to protect the wire from abrasions
- **Grounding.** a separate grounding conductor shall be installed in the raceway

CONSTRUCTION

- **Construction.** Shall be made of rigid (nonplasticized) polyvinyl chloride
- **Marking.** PVC shall be clearly and durably marked at least every 3000mm

HIGH DENSITY POLYETHYLENE CONDUIT: TYPE HDPE CONDUIT

HIGH DENSITY POLYETHYLENE (HDPE) CONDUIT – It is a nonmetallic raceway of circular cross section, with associated couplings, connectors, and fittings for the installation of electrical conductors

Uses Permitted

1. In discrete lengths or in continuous lengths from a reel
2. In locations subject to severe corrosive influences subject to chemicals
3. In cinder fill
4. In direct burial installations in earth or concrete
5. Above ground, where encased in not less than 50 mm of concrete

6. Conductors or cables rated at a temperature higher than the listed temperature rating of HDPE conduit shall be permitted to be installed in HDPE conduit, provided the conductors or cables are not operated at temperature higher than the listed temperature rating of the HDPE conduit.

Uses not Permitted

1. Where exposed
2. Within a building
3. In any hazardous (classified) location
4. Ambient temperatures in 50 degrees Celsius

Size (shall not be used)

Minimum – Smaller than metric designator 16 (trade size ½)

Maximum – Larger than metric designator 155 (trade size 6)

Number of Conductors. shall not exceed that permitted to percentage fill Cables shall also be permitted to be installed

Bends – How Made

- Shall be so made that the conduit will not be damaged and internal of the diameter will not be effectively reduced
- Made manually without use of auxiliary equipment
- metric designators of 129 and 155 (trade sizes 5 & 6) the allowable radii shall be in accordance with specifications provided by the manufacturer

Bends – Number in One Run. Not be more than four quarter bends (360 degrees in total) between pull points (conduit bodies and boxes)

Trimming. All cut ends shall be trimmed inside and outside to remove rough edges

Bushings. A bushing or adapter shall be provided to protect the wire from abrasion unless the enclosure design provides equivalent protection

Joints. shall be made by an approved method

Grounding. Where equipment grounding is required, a separate equipment grounding conductor shall be installed in the conduit

Exception

1. *The equipment grounding shall be permitted to be run separately from the conduit where used for grounding dc circuits*
2. *The equipment grounding conductor shall not be required where the grounded conductor is used to ground equipment*

Construction

- Composed of high density polyethylene that is resistant to moisture and chemical atmospheres
- Material shall be resistant to moisture and corrosive agents and shall be sufficient strength to withstand abuse

Marking. Each length of HDPE shall be clearly and durably marked every 3000mm. Type of material shall also be included

NONMETALLIC UNDERGROUND CONDUIT WITH CONDUCTORS: TYPE NUCC

NONMETALLIC UNDERGROUND CONDUIT WITH CONDUCTORS – a factory assembly of conductors or cables inside a nonmetallic, smooth wall raceway with a circular section

Uses Permitted

1. Direct burial underground installation
2. Encased or embedded in concrete
3. In cinder fill
4. In underground locations subject to severe corrosive influences subject to chemicals for which the assembly is specifically approved
5. Aboveground, where encased in not less than 50mm of concrete

Uses not Permitted

1. In exposed locations
2. Inside buildings

Exception: The conductor or the cable portion of the assembly, where suitable, shall be permitted to extend within the building for termination purposes

3. In any hazardous (classified) location

Size (shall not be used). Minimum – Smaller than metric designator 16 (trade size ½)

Maximum – Larger than metric designator 155 (trade size 6)

Number of Conductors. The number of conductors or cables shall not exceed that permitted by the percentage fill

Bends – How Made. Manually made so that the conduit will not be damaged and the integral diameter of the conduit will not be effectively reduced

Bends – Number in One Run. Not more than equivalent of four quarter bends between termination points

Conductor Terminations. All terminations between the conductors or cables and equipment shall be made by an approved method for that type of conductor or cable

Splices and Taps. shall be made in junction boxes or other enclosures

Grounding. Where equipment grounding is required, an assembly containing a separate equipment grounding conductor shall be used

Conductor Fill. Shall not exceed that permitted by the percentage fill

Marking. NUCC shall be marked clearly and durably marked at least ever 3000mm. The type of conduit material shall also be included in the marking.

REINFORCED THERMOSETTING RESIN CONDUIT: TYPE RTRC

REINFORCED THERMOSETTING CONDUIT (RTRC) – a rigid nonmetallic raceway of circular cross section, with integral or associated couplings, connectors, and fittings for the installation of electrical conductors and cables.

Uses Permitted

1. Concealed
2. Corrosive Influences
3. Cinders – in cinder fills
4. Wet locations - where walls are frequently washed, the entire conduit system, including boxes and fittings used therewith, shall be installed and equipped so as to prevent water from entering the conduit

5. Dry and Damp Locations
6. Exposed – if identified for such use
7. Underground Installations
8. Support for Conduit Bodies – shall be permitted to support nonmetallic conduit bodies not larger than the largest trade size of an entering raceway.
9. Insulation Temperature Limitations – Conductors or cables rated at a temperature higher than the listed temperature rating of RTRC conduit shall be permitted to be installed in RTRC conduit, if conductors or cables are not operated at a temperature higher than the listed temperature rating of the RTRC conduit.

Uses not Permitted

1. Hazardous (Classified) Locations
   - *In Class I, Division 2 locations*
2. Support for Luminaires
3. Physical Damage
4. Ambient temperatures in excess 50 degrees Celsius
5. Theaters and Similar Locations

Bends – Number in One Run. Shall not be more than the equivalent of four quarter bends

Trimming. All cut end shall be trimmed inside and out

Securing and Supporting. Installed as a complete system and be securely fastened in place and supported

Number of Conductors. Shall not exceed that permitted by the percentage fill. Cables shall be permitted to be installed and number of cables shall not exceed the allowable percentage fill

- Supports – shall be supported as required. Horizontal runs of RTRC supported by openings through framing members at intervals not exceeding and securely fastened within 900mm of termination points

Expansion Fittings. Provided to compensate for thermal expansion and contraction where the length change is expected to be 6mm or greater in a straight run between securely mounted items (boxes, cabinets, elbows or other conduit terminators)

Bushings. A bushing or adapter shall be provided to protect the wire from abrasion unless the enclosure design provides equivalent protection

Joints. Shall be made in an approved method

Grounding. Where equipment grounding is required, a separate grounding conductors shall be installed

Marking. Each length marked at least every 3000mm and is permanently marked for aboveground use

Construction

- For use aboveground it shall be flame retardant, resistant to impact, resistant to distortion from heat under conditions, and resistant to low temperature and sunlight effects
- For use underground, shall be resistant to moisture and corrosive agents. For direct burial, without encasement of concrete, shall be capable of withstanding continued loading
- Composed of suitable nonmetallic material that is resistant to moisture and chemical atmospheres
- To be surface marked to indicate special characteristics of the material

LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT: TYPE LFNC

LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT – a raceway of circular cross section of various types as follows:

1. A smooth seamless inner core and cover bonded together and having one or more reinforcement layers between cores, designated type LFNC-A
2. A smooth inner surface with integral reinforcement within the raceway wall, designated as Type LFNC-B
3. A corrugated internal and external surface without integral reinforcement within the raceway wall, designated as LFNC-C

Uses Permitted

1. Flexibility is required for installation, operation or maintenance
2. Protection of the contained conductors from vapors, liquids or solids
3. For outdoor locations where listed and marked as suitable for the purpose
4. Direct burial
5. Type LFNC-B shall be permitted to be installed in lengths longer than 1800mm

6. Type LFNC-B, a manufactured prewired assembly, metric designator 16 through 27 (trade size ½ through 1) conduit
7. For encasement in concrete where listed for direct burial

Uses not Permitted

1. *Subject to physical damage*
2. *Any combination of ambient conductor temperatures in excess of that for which the LFNC is approved*
3. *Lengths longer than 1800mm, or where a longer length is approved as essential for a required degree of flexibility*
4. *In any hazardous (classified) location*

SIZE (SHALL NOT BE USED)

Minimum – smaller than metric designator 16 (trade size ½) and for metric designator 12 (trade size 3/8)

(1) For enclosing the leads in motors

(2) In lengths not exceeding1800mm as part of a listed assembly for tap connections to luminaires or for utilization equipment

Maximum – larger than metric designator 103 (trade size 4)

Securing and Supporting

- Installed in lengths 1800mm, the conduit shall be securely fastened at intervals not exceeding 900mm and within 300mm of each side of every outlet box, junction box, cabinet, or fitting.
- Securing or supporting of the conduit shall not be required where it is fished, installed in lengths not exceeding 900mm at terminals where flexibility is required, not even exceeding 1800mm from a luminaire terminal.
- Horizontal runs of LFNC supported by openings through farming members at intervals not exceeding 900mm and securely fastened within 300mm of termination points.

- Securing or supporting shall not be required where installed in lengths not exceeding 1800mm from the last point where the raceway is securely fastened for connections within an accessible ceiling to a luminaire(s) or other equipment.

COUPLINGS AND CONNECTORS.

Only fittings listed for use with LFNC shall be used. Angle connectors shall not be used for concealed raceway installations. Straight LFNC fittings are permitted for direct burial or encasement in concrete

Groundings. Where equipment grounding is required, a separate equipment grounding conductor shall be installed in the conduit

Construction Specifications

Construction. LFNC-B as a prewired manufactured assembly

- ❖ provided in continuous lengths capable of being sipped in a coil, reel, or carton without damage

Marking. Shall be marked at least every 600mm Marking include a type designation and the trade size. Conduit intended for outdoor use or direct burial shall be marked.

- ❖ The type, size, and quantity of conductors used in prewired manufactured assemblies shall be identified by means of a printed tag or label attached to each end of the manufactured assembly and either the carton, coil, or reel.

ELECTRICAL METALLIC TUBING:TYPE EMT

FLEXIBLE ELECTRICAL METALLIC TUBING: TYPE FMT

ELECTRICAL NONMETALLIC TUBING: TYPE ENT

GUTTERS

ELECTRICAL METALLIC TUBING: TYPE EMT

- **Electrical Metallic Tubing (EMT).** An unthreaded thin wall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings, EMT is generally made of steel (ferrous) with protective coatings or aluminum (nonferrous).

Uses Permitted

- ❑ Exposed and Concealed
- ❑ Corrosive Environments
- ❑ Cinder Fill
- ❑ Wet Locations

Uses Not Permitted

- ❑ Where subject to physical damage
- ❑ Where protected from corrosion solely by enamel
- ❑ Dissimilar Metals

Size

- Minimum

EMT smaller that metric designator 16 shall not be used (trade size ½)

- Maximum

Metric designator 103 (trade size 4)

- **Bends-How Made.** Shall be made so that the tubing shall not be damaged as well as the internal diameter not be effectively reduced.
- **Bends-Number in One Run.** Shall not be more than the equivalent of four quarter bends (360 degrees total) between pull points.
- **Threading.** EMT **shall not** be threaded
- **Reaming.** All cut ends shall be reamed
- **Couplings and Connectors.** Couplings and connectors used with EMT shall be made up tight.
- **Grounding.** EMT shall be permitted as an equipment grounding conductor
- **Marking.** EMT shall be clearly and durably marked at least every 3000mm

FLEXIBLE ELECTRICAL METALLIC TUBING: TYPE FMT

- **Flexible Metallic Tubing (FMT)** - a metal raceway that is circular in cross section, flexible and liquidtight without a non metallic jacket

Uses Permitted

(1) In dry location

(2) Where concealed

(3) In accessible locations

(4) For system voltages of 1000 volts maximum

Uses not Permitted

- In hoist ways
- In storage battery rooms
- Hazardous locations unless permitted in the code
- Underground for direct earth burial
- Where subject to physical damage
- In length over 1800mm

Size

- **Minimum**

FMT smaller than metric designator 16 (trade size 3/8) shall not be used.

- **Maximum**

Shall be metric designator 21mm (trade size ¾)

- **Grounding.** Shall be permitted as an equipment grounding conductor

Infrequent Flexing Use. The radii of bends shall not be less than specified in table below.

Metric Designator	Trade Size	Minimum Radii for Flexing Use (mm)
12 mm	3/8	250
16 mm	½	310
21 mm	3/4	440

Fixed Bends. Where FMT is bent for installation purposes and is not flexed or bent, the radii of bends shall not be less than specified in table.

Metric Designator	Trade Size	Minimum Radii for Flexing Use (mm)
12 mm	3/8	90
16 mm	½	100
21 mm	3/4	125

ELECTRICAL NONMETALLIC TUBING: TYPE ENT

Electrical Nonmetallic Tubing (ENT) - a nonmetallic, pliable, corrugated raceway of circular cross section with integral or associated couplings, connectors and fittings for the installation of electrical conductors. ENT is resistant to moisture and chemical atmosphere and is flame retardant.

Uses Permitted

1. In any building not exceeding three floors above grade
2. ENT shall be concealed within walls, floors and ceilings
3. In location subject to severe corrosive influences and is material is specifically approved
4. In concealed, dry and damp locations that are specifically allowed
5. Above suspended ceilings where the suspended ceilings in buildings protected with sprinklers system
6. For wet location indoors as permitted in a slab below grade with fittings listed for the purpose
7. Metric designator 16 through 27 as listed manufactured prewired assembly

Uses Not Permitted

1. In any hazardous (classified) location, except as permitted in this code
2. For the support of luminaires and other equipment
3. Where subject to ambient temperature on excess of 50 degree Celsius
4. For direct earth burial and in exposed locations
5. Where the voltage is over 600 volts
6. Where exposed to the direct rays of the sun, unless identified as sunlight resistant.
7. Where subject to physical damage

Size

- **Minimum**

ENT smaller that metric designator 16 shall not be used

(trade size ½)

- **Maximum**

ENT larger than metric designator 53 (trade size 2) shall not be used

- **Bends-How Made.** shall be made so that the tubing shall not be damaged as well as the internal diameter not be effectively reduced.
- **Trimming.** All cut ends shall be trimmed inside and outside
- **Securing and Supporting.** shall be securely fastened in place and supported in accordingly.
- **Bushings.** bushing or adapter shall be provided to protect the wire from abrasions
- **Grounding.** a separate grounding conductor shall be installed in the raceway

AUXILIARY GUTTERS

- **Metal Auxiliary Gutters** - a sheet of metal enclosure used to supplement wiring spaces at meter centers, switchgears, switchboards and similar points of wiring systems.
- **Nonmetallic Auxiliary Gutters** - A flame-retardant, nonmetallic enclosure used to supplement wiring spaces at meter centers, distribution centers, switchgear, switchboards and similar points of wiring systems

Uses Permitted

- **Sheet Metal Auxiliary Gutters**
  1. Shall be permitted in Indoor and Outdoor Use.
  2. metal auxiliary gutters shall be suitable for such locations.
- **Nonmetallic Auxiliary Gutters**
  1. Nonmetallic auxiliary gutters shall be permitted to be installed outdoors.
  2. Shall be permitted to be installed indoors

Uses Not Permitted

- To enclose switches, overcurrent devices, appliances, or other similar equipment.
- To extend a greater distance than 9000 mm beyond the equipment that it supplement

- Number of Conductors

  Sheet Metal and Nonmetallic Auxiliary Gutters . the sum of the cross-sectional areas of all contained conductors and cables at any cross section of a sheet metal auxiliary gutter shall not exceed 20% of the interior cross sectional area of the metal sheet auxiliary gutter.

Ampacity

- **Sheet Metal Auxiliary Gutters.** Current-carrying conductors contained is 30 or less.

  Copper bars- not to exceed 1.55 Amperes/mm^2

  Aluminum bars- not to exceed 1.09 Amperes/mm^2

- **Nonmetallic Auxiliary Gutters.** adjustment factors shall be applicable to the current carrying conductors in the nonmetallic auxiliary gutter

Securing and Supporting

- **Sheet Metal Auxiliary Gutters.**

  Shall be supported and secured throughout their entire length at intervals not exceeding 1500mm.

- **Nonmetallic Auxiliary Gutters**

  shall be supported and secured at intervals not to exceed 900mm and at each end of joint, unless listed for other support intervals. In no case shall the distance between supports shall exceed 3000mm

Construction

- ❑ Electrical and Mechanical Continuity
- ❑ Substantial Construction
- ❑ Smooth Rounded Edges
- ❑ Shall be securely fastened to the gutter
- ❑ Clearance of Bare Live Parts

Marking

- **Outdoors**
  - (1) Suitable for exposure to sunlight
  - (2) Suitable for use in wet locations
  - (3) Installed conductor insulation temperature rating
- **Indoors.** Nonmetallic auxiliary gutters installed indoors shall be marked with the installed conductor insulation temperature rating

- ❑BUSWAYS
- ❑CABLEBUS
- ❑CELLULAR CONCRETE FLOOR RACEWAYS
- ❑CELLULAR METAL FLOOR RACEWAYS

BUSWAYS

A raceways consisting of a metal enclosure containing factory-mounted, bare or insulated conductors, which are usually copper or aluminum bars, rods, or tubes.

USES PERMITTED

(A) EXPOSED

(B) BEHIND ACCESS PANELS.

(C) TROUGH WALLS AND FLOORS

USES NOT PERMITTED

(A) PHYSICAL DAMAGE/ CORROSIVE VAPORS

(B) HOISTWAYS

(C) HAZARDOUS LOCATIONS

(D) WET LOCATIONS

(E) WORKING PLATFORM

OVERCURRENT PROTECTION

RATING OF OVER CURRENT PROTECTION – FEEDERS

A busways shall be protected against overcurrent in accordance with the allowable current rating of the busway.

REDUCTION IN AMPACITY SIZE OF BUSWAY

Overcurrent protection shall be required where busways are reduced in ampacity.

Exception: For industrial establishments only, omission of overcurrent protection shall be permitted at points where busways are reduced in ampacity, provided that the length of the busway having the smaller ampacity does not exceed 15 m and has an ampacity at least equal to one-third the rating or setting of the overcurrent device

FEEDER OR BRANCH CIRCUITS

Where a busway is used as a feeder, devices or plug-in connections for tapping off feeder or branch circuits from the busway shall contain the overcurrent devices required for the protection of the feeder or branch circuits.

Rating of Overcurrent Protection — Branch Circuits

A busway used as a branch circuit shall be protected against overcurrent in accordance with 2.10.2.2.

Support

Busways shall be securely supported at intervals not exceeding 1500 mm unless otherwise designed and marked.

Branches from Busways

(A) General - Branches from busways shall be permitted to use any of the following wiring methods:

(1) Type AC armored cable

(2) Type MC metal-clad cable

(3) Type MI mineral-insulated, metal-sheathed cable

(4) Type IMC intermediate metal conduit

(5) Type RMC rigid metal conduit

(6) Type FMC flexible metal conduit

(7) Type LFMC liquidtight flexible metal conduit

(8) Type PVC rigid polyvinyl chloride conduit
(9) Type RTRC reinforced thermosetting resin conduit
(10) Type LFNC liquidtight flexible nonmetallic conduit
(11) Type EMT electrical metallic tubing
(12) Type ENT electrical nonmetallic tubing
(13) Busways
(14) Strut-type channel raceways
(15) Surface metal raceways
(16) Surface nonmetallic raceways

B) Cord and Cable Assemblies

(1) The cord or cable shall be attached to the building by an approved means.

(2) The length of the cord or cable from a busway plug-in device to a suitable tension take-up support device shall not exceed 1800 mm.

(3) The cord and cable shall be installed as a vertical riser from the tension take-up support device to the equipment served.

(C) Branches from Trolley-Type Busways - Suitable cord and cable assemblies approved for extra-hard usage or hard usage and listed bus drop cable shall be permitted as branches from trolley-type busways for the connection of movable equipment.

Dead Ends - A dead end of a busway shall be closed.

Grounding - Busway shall be connected to an equipment grounding conductor(s), to an equipment bonding jumper, or to the grounded conductor where permitted or required by 2.50.5.3(B)(1) or 2.50.7.13.

Marketing – Busways shall be marked with the voltage and current rating for which they are designed, and with the manufacture's name or trademark in such a manner as to be a visible after installation.

REQUIREMENTS FOR OVER 600 VOLTS, NOMINAL

Adjacent and Supporting Structures - Metal-enclosed busways shall be installed so that temperature rise from induced circulating currents in any adjacent metallic parts will not be hazardous to personnel or constitute a fire hazard.

Barriers and Seals

(a) Vapor Seals - Busway runs that have sections located both inside and outside of buildings shall have a vapor seal at the building wall to prevent interchange of air between indoor and outdoor sections.

(b) Fire Barriers - Fire barriers shall be provided where fire walls, floors, or ceilings are penetrated.

Drain Facilities – Drain plugs, filter drains, or similar methods shall be provided to remove condensed moisture from low points in busway run.

Ventilated Bus Enclosures - Ventilated busway enclosures shall be installed in accordance with Part 1.10.3, and 4.90.2.4.

Terminations and Connections - Where bus enclosures terminate at machines cooled by flammable gas, seal-off bushings, baffles, or other means shall be provided to prevent accumulation of flammable gas in the busway enclosures.

Switches - Switching devices or disconnecting links provided in the busway run shall have the same momentary rating as the busway.

Wiring 600 Volts or Less, Nominal - Secondary control devices and wiring that are provided as part of the metal-enclosed bus run shall be insulated by fire-retardant barriers from all primary circuit elements with the exception of short lengths of wire, such as at instrument transformer terminals.

Expansion Fittings - Flexible or expansion connections shall be provided in long, straight runs of bus to allow for temperature expansion or contraction, or where the busway run crosses building vibration insulation joints.

Neutral Conductor - Neutral bus, where required, shall be sized to carry all neutral load current, including harmonic currents, and shall have adequate momentary and short-circuit rating consistent with system requirements.

Grounding - Metal-enclosed busway shall be grounded.

Marking - Each busway run shall be provided with a permanent nameplate on which the following information shall be provided:

(1) Rated voltage.

(2) Rated continuous current; if bus is forced-cooled, both the normal forced-cooled rating and the self-cooled (not forced-cooled) rating for the same temperature rise shall be given.

(3) Rated frequency.

(4) Rated impulse withstand voltage.

(5) Rated 60-Hz withstand voltage (dry).

(6) Rated momentary current.

(7) Manufacturer's name or trademark.

CABLEBUS

An assembly of units or sections with insulated conductor having associated fittings forming a structural system used to securely fasten or support conductors and conductor terminations in a completely enclosed, ventilated, protective metal housing. This assembly is designed to carry fault current and to withstand the magnetic forces of such current.

Uses Permitted - Approved cablebus shall be permitted :

(1) At any voltage or current for which spaced conductors are rated and where installed only for exposed work, except as permitted in 3.70.2.9

(2) For branch circuits, feeders, and services

(3) To be installed outdoors or in corrosive, wet, or damp locations where identified for the use

Uses Not Permitted – Cablebus shall not be permitted to be installed in the following:

(1) Hoistways

(2) Hazardous (classified locations), unless specifically permitted in Chapter 5

CABLE BUS INSTALLATION

(A) **Transversely Routed** – Cablebus shall be permitted to extend transversely through partitions or walls, other than fire walls, provided that the section within the wall is continuous, protected against physical damage, and unventilated.

(B) **Through Dry Floors and Platforms** – Cablebus shall be permitted to extend vertically through dry walls and platforms, provided that the cablebus is totally enclosed at the point where it passes through the floor or platform and for a distance of 1800 mm above the floor or platform.

(C) Through Floors and Platforms in Wet Locations – Cablebus shall be permitted to extend vertically through floors and platforms in wet locations where :

(1) There are curbs or other suitable means to prevent waterflow through the floor or platform opening and

(2) Where the cablebus is totally enclosed at the point where it passes through the floor or platform and for a distance of 1800 mm above the floor or platform.

CONDUCTOR SIZE AND TERMINATION

(A) **Conductor** – The current-carrying conductors in cablebus shall be:

(1) Have insulation rating of 75℃ or higher and be of an approved type suitable for the application.

(2) Be sized in accordance with the design of the cablebus but in no case be smaller than 50 mm^2.

(B) **Termination** - Approved terminating means shall used for connections to cablebus conductors.

Number of Conductors - The number of conductors shall be that for which the cablebus is designed.

Overcurrent Protection – Cablebus shall be protected against overcurrent in accordance with the allowable ampacity of the cablebus conductors in accordance with 2.40.1.4

Securing and Supporting

(A) **Cablebus supports** – Cablebus shall be securely supported at intervals not exceeding 3700 mm. Where spans longer than 3700 mm are required, the structure shall be specifically designed for the required span length.

Conductors Supports – The individual conductors in a cablebus shall be supported at intervals not greater than 900 mm for horizontal runs and 450 mm for vertical runs.

Fittings – A cablebus system shall include improved fittings for the following:

(1) Changes in horizontal or vertical direction of the run

(2) Dead Ends

(3) Terminations in or on connected apparatus or equipment or the enclosure for such equipment

(4) Additional physical protection were required, such as guards where subject to severe physical damage.

Grounding – A cablebus system shall be grounded and/or bonded as applicable.

Construction Specification

Marking – Each section of cablebus shall be marked with the manufacturer's name or trade designation and the maximum diameter, number, voltage rating, and ampacity of the conductors shall be installed.

CELLULAR CONCRETE FLOOR RACEWAYS

Cell – A single, enclosed tabular space in a floor made of precast cellular concrete slabs, the direction of the cell being parallel to the direction of the floor member.

Header – Transverse metal raceways for electrical conductors, providing access to predetermined cells of a precast cellular concrete floor, thereby permitting the installation of electrical conductors from a distribution center to the floor cells.

Uses Not Permitted – Conductors shall not be installed in precast cellular concrete floor raceways as follows:

(1) Where subject to corrosive vapor

(2) In any hazardous (classified) location, except as permitted by other articles in this Code

(3) In commercial garages, other than for supplying ceiling outlets or extensions to the area below the floor but not above.

Cellular Concrete Floor Ways Installation – Installation of cellular concrete floor ways shall comply with 3.72.2.7(A) through 3.72.7(E).

(A) **Header** – shall be installed in a straight line at right angles to the cells. The header shall be mechanically secured to the top of the precast cellular concrete floor. The end joints shall be closed by a metal closure fitting and sealed against the entrance of the concrete. The header shall be electrically continuous throughout its length and shall be electrically bonded to the enclosure of the distribution center.

(B) **Connections to Cabinets and Other Enclosures** – Connections from headers to cabinets and other enclosures shall be made by means of listed metal raceways and listed fittings.

(C) **Junction Boxes** – Shall be leveled to the floor grade and sealed against the free entrance of water or concrete. Junction boxes shall be of metal and shall be mechanically and electrically continuous with the header.

(D) **Inserts** – Shall be leveled and sealed against the entrance of concrete. Inserts shall be of metal and shall be fitted with grounded-type receptacles. A grounding conductor shall connect the insert receptacles to a positive ground connection provided on the header.

(E) **Markers** – A suitable number of markers shall be installed for the future location of cells.

Size of Conductors – No conductors larger than $50mm^2$ shall be installed.

Maximum Number of Conductors – The combined cross-sectional area of all conductors or cables shall not exceed 40 percent of the cross-sectional area of the cell or header.

Splices and Taps – shall be made only in headers access units or junction boxes.

Discontinued Outlets – When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceways.

CELLULAR METAL FLOOR RACEWAYS

Cellular Metal Floor Raceways – The hollow spaces of cellular metal floor, together with suitable fitting, that may be approved as enclosed channel for electrical conductors.

Cell – A single enclosed tabular space in a cellular metal floor member, the axis of the cell being parallel to the axis of the metal floor member.

Header – A transverse raceways for electrical conductors, providing access to predetermined cells od a cellular metal floor, thereby permitting the installation of electrical conductors from a distribution center to the cells.

Uses Not Permitted

Conductors shall not be installed in cellular metal floor raceways as follows:

(1) Where subject is to corrosive vapor

(2) In any hazardous (classified) location, except as permitted by other articles in this code

(3) In commercial Garages, other than for supplying ceiling outlets or extensions to the area below the floor but not above

Cellular Metal floor Raceways Installations shall comply with 3.74.2.7(A) through 3.74.2.7 (D).

(A) Connections to Cabinets & Extension from cells – Shall be made by means of liquidtight flexible metal conduit, flexible metal conduit where not installed in concrete, rigid metal conduit, intermediate metal conduit, electrical metal tubing, or approved fittings. Where are provisions for the termination of an equipment grounding conductor, rigid polyvinyl chloride conduit shall be permitted.

(B) Junction Boxes – Shall be leveled to the floor grade and sealed against the free entrance of water or concrete. Junction boxes used with these raceways shall be of metal and shall be electrically continuous with the raceway.

(C) **Inserts** – Shall be leveled to the floor grade and sealed against the entrance of concrete. Inserts shall be of metal and shall be continuous with the raceway. In cutting through the cell wall and settings inserts, chips and other dirt shall not be allowed to remain in the raceway, and tools shall be used that are designed to prevent the tool from entering the cell and damaging the conductors.

(D) **Markers** – A suitable number of markers shall be installed for locating cells in the future.

Size of Conductors – No conductor larger than $50mm^2$ shall be installed.

Maximum Number of Conductors in Raceways – The combined cross-sectional area of all conductors or cables shall not exceed 40 percent of the interior cross-sectional area of the cell or header.

Ampacity of Conductors – The ampacityadjusments factors in 3.10.2.6(B)(3) shall apply to conductors installed in cellular metal floor raceways.

Splices and Taps – Shall be made only in header access units or junction boxes.

Discontinued Outlets – When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceway.

Construction Specifications

General – Cellular metal floor raceways shall be constructed so that adequate electrical and mechanical continuity of the complete system will be secured.

Metal Wireways

Metal Wireways- Sheet metal troughs with hinged or removable covers for housing and protecting electrical wires and cables in which conductors are laid in place after the raceways has been installed as a complete system.

Uses permitted

- For exposed work
- In any hazardous (classified) location, as permitted be other articles in this *code*.
- In wet locations where wireways are listed for the purpose.
- Concealed spaces as an extension that passes transversely through walls, if the length passing through the wall is unbroken. Access to the conductors shall be maintained on both sides of the wall.

Uses not Permitted

- Where subject to physical damage
- Where subject to severe corrosive environments

Installation-**Conductors connected in parallel**

- where single conductor cables compromising each parallel, neutral, or grounded conductor of an alternating-current circuit are connected in parallel as permitted in 3. 10.2.2 (H), the conductors shall be installed in groups consisting of not more than one conductor per phase, neutral, or grounded conductor to prevent current imbalance in the paralleled conductors due to inductive reactance.

Installation-Number of conductors and ampacity

A. **Cross-sectional areas of wireway**- the sum of the cross-sectional areas of all contained conductors and cables at any cross-section of a wireway shall not exceed 20 percent of the interior cross-sectional area of the wireway.

B. **Adjustment factors**- the adjustment factors shall be applied only where the number of current-carrying conductors, including neutral conductors classified as current-carrying under the provisions exceeds 30. Conductors for signaling circuits of controller conductors between a motor and its starter and used only for starting duty shall not be considered as current-carrying conductors.

Installation-Securing the supporting

A. **Horizontal support**- wireways shall be supported where run horizontally at each end and at intervals not to exceed 1 500 mm or for individual lengths longer than 1 500 mm at each end or joint, unless listed for other support intervals. The distance between supports shall not exceed 3 mm.

B. **Vertical support**- vertical runs of wireways shall be securely supported at intervals not exceeding 4.5 m (15 ft) and shall not have more than one joint between supports. Adjoining wireway sections shall be securely fastens together to provide a rigid joint.

Installation-Splices, taps and power distribution blocks

A. **Splices taps**- The conductors, including splices and taps, shall not fill the wire-way to more than 75 percent of its area.

B. **Power distribution blocks**

1) Installation- Power distribution blocks installed on the line side of the service equipment shall be marked “suitable for use on the line side of service equipment” or equivalent.

2) Size of enclosure- the power distribution block shall be installed in a wireway with dimensions not smaller than specified in the installation instructions of the power distribution block.

3) Wire bending space- wire bending space at the terminals of power distribution blocks shall comply with 3.12.1.6(B).

4) Live parts- power distribution blocks shall not have uninsulated live parts exposed within a wireway, whether or not the cover is installed.

5) Conductors- conductors shall be arranged so the power distribution block terminals are unobstructed following installation.

Construction specification-**Construction**

A. **Electrical and Mechanical Continuity**- Wireways constructed and installed shall have electrical and mechanical continuity of the complete system.

B. **Substantial Construction**- Wireways shall be of substantial construction and shall provide a complete enclosure for the contained conductors and be suitably protected from corrosion.

C. **Smooth Rounded Edges**- Suitable bushings, shields, or fittings having smooth, rounded edges shall be provided at all locations where necessary to prevent abrasion of the insulation of the conductors.

D. **Covers**- Covers shall be securely fastened to the wireway.

Multioutlet Assembly

Multioutlet Assembly- a type of surface, flush, or free standing raceway designed to hold conductors and receptacles, assembled in the field or at the factory.

Installation-Uses permitted

- The use of multi-outlet assembly shall be permitted in dry location.

Installation-Uses not permitted

- A multi-outlet assembly shall not be installed as follows:

A. Where concealed, except that it shall be permissible to surround the back and sides of a metal multi-outlet assembly by the building finish or recess a nonmetallic multi-outlet assembly in a baseboard.

B. Where the subject to severe physical damage.

C. Where the voltage is 300 volts or more between conductors unless the assembly is of metal having a thickness of not less than1.02mm.

D. Where subject to corrosive vapors.

E. In hoistways.

F. In any hazardous (classified) location, except as permitted by other articles in this Code.

Installation-**Insulated Conductors**

- For field-assembled multi-outlet assemblies, insulated conductors shall comply with (A) and (B). As applicable.

A. **Deflected insulated conductors** – Where insulated conductors are deflected within a nonmetallic wireway, either at the ends or where conduits, fittings, or other raceways or cables enter or leave the nonmetallic wireway.

B. **Multioutlet Assemblies Used as Pull Boxes** – Where insulated conductors 22 mm^2 or larger are pulled through a wireway, the distance between raceway and cable entries enclosing the same conductor shall not be less than that required in 3.14.2.14(A)(1) for straight pulls and in 3.14.2.14(A)(2) for angle pulls. When transposing cable size into racerway size, the minimum metric designator (trend size) raceway required for the number and size of conductors in the cable shall not be used.

NONMETALLIC EXTENSIONS

Concealable Nonmetallic Extension- A listed assembly of two, three, or four insulated circuit conduction within nonmetallic jacket, an extruded thermoplastic covering or a sealed nonmetallic covering. The classification includes surface extension intended for mounting directly on the surface of walls or ceilings, and concealed with paint, testier, joint compound, plaster, wallpaper, tile, wall paneling, or other similar materials.

Nonmetallic Extension- An assembly of two insulated conductors within a nonmetallic jacket or an extruded thermoplastic covering. The classification includes surface extension intended for mounting directly on the surface of walls of ceilings.

Listing Requirements

- Concealable nonmetallic extensions and associated fittings and devices shall be listed. The starting/source tap device for the extension shall contain and provide the following protection for all load-side extension and devices.

1) Supplementary overcurrent protection.
2) Level of protection equivalent to a Class A GFCI
3) Level of protection equivalent to a portable GFCI
4) Line and load-side mis wire protection
5) Provide protection from the effects of are faults.

Installation-**Uses permitted**

A. **From and Existing Outlet** – The extension shall be from an existing outlet on a 15-or 20-ampere branch circuit, where concealable nonmetallic extension is from a non-grounding-type receptacle.

B. **Exposed and in Dry Location**-The extensive shall be run exposed, or concealed as permitted, and in a dry location.

C. **Residential or Offers**-The building shall be occupied for residential or the office purposes and shall not exceed three floors, above grade. Where identified for the use, concealable nonmetallic extension shall be permitted more than three floors above grade.

Installation-**Uses not permitted**

- Nonmetallic extensions shall not be used as follows:

A. In unfinished basements, attics, or roof spaces.

B. Where the voltage between conductors exceed 150 volts for nonmetallic surface extension and 300 volts for aerial cable.

C. Where subject to corrosive vapors.

D. Where run through a floor or partitions, or outside the room in which it originates.

Installation-**Exposed**

A. **Nonmetallic Extension**- One or more extensions shall be permitted to be run in any directions from an existing outlet, but on the floor or within 50 mm from the floor.

B. **Concealable Nonmetallic Extension**- Where identified for the use, nonmetallic extension shall be permitted to be concealed with paint, texture, concealing compound , plaster, wallpaper, tile, wall paneling, or other similar materials.

Installation-**Bends**

A. **Nonmetallic extension** – A bend that reduces the normal spacing between the conductors shall be covered with a cap to protect the assembly from physical damage.

B. **Concealable Nonmetallic Extensions**- Concealable extensions shall be permitted to be folded back over themselves and flattened as required for installation.

Installation-Securing and Supporting

A. **Nonmetallic Extension-** Nonmetallic surface extension shall be secured in a place by approved means at intervals not exceeding 200 mm, with an allowance for 300 mm to the first fastening where the connection to the supplying outlet is by means of an attachment plug.

B. **Concealable Nonmetallic Extensions-** All surface-mounted concealable nonmetallic extension components shall be firmly anchored to the wall or ceiling using adhesive or mechanical anchoring system identified for use.

Installation-**Boxes and Fittings**

- **Receptacles**- All receptacle housings, and self-contained devices used with concealable nonmetallic extension shall be identified for use.
- **Receptacles and Housing**- Receptacle housings and self-contained devices designed either for surface or for recessed mounting shall be permitted for use with concealable nonmetallic extensions.

Construction specification-Marking

A. **Cable** – Concealable nonmetallic extension shall be clearly and durably marked of both sides at intervals of not more than 610 mm with the information required by 3.10.3.17(A) and with the following additional information:

1) Material of conductors
2) Maximum temperature rating
3) Ampacity

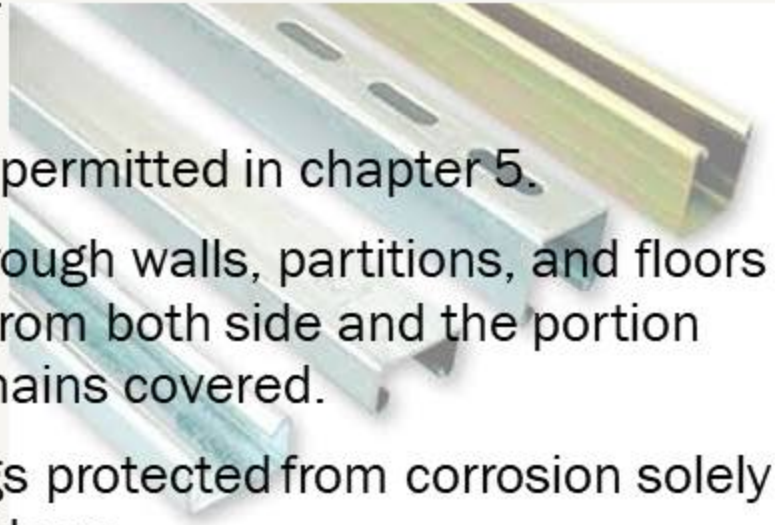
B. **Conductor Identification** – Conductors shall be clearly and durably identified on both side throughout their length.

Strut-Type Channel Raceways

Strut-type Channel Raceway- A metal raceway that is intended to be mounted to the surface of or suspended from a structure, with associated accessories for the installation of electrical conductors and cables.

Installation-Uses permitted

1) Where exposed.
2) In dry location.
3) In location subject to corrosive vapors where protected by finishes approved for the condition.
4) Where the voltage is 600 volts or less.
5) As power poles.
6) In hazardous (classified) location as permitted in chapter 5.
7) As extension of unbroken lengths through walls, partitions, and floors where closure strips are removable from both side and the portion within the wall, partition, or floor remains covered.
8) Ferrous channel raceways and fittings protected from corrosion solely by enamel shall be permitted only indoors.



Installation-Uses not permitted

- Strut-type channel raceway shall not be used as follows:

A. Where concealed

B. Ferrous channel raceways and fittings protected from corrosion solely by enamel shall not be permitted where subject to severe corrosive influences.

Installation-Size of Conductors

- No conductor larger than that for which the raceway is listed shall be installed in strut-type channel raceway.

Installation-Number of Conductors

- The adjustment factors shall not be apply to conductors installed in the strut-type channel raceways where all of the following condition are met:

1) The cross-sectional area of the raceway exceeds 2500 mm^2
2) The current-carrying conductors do not exceed 30 mm in number.
3) The sum of the cross-sectional area of all contained conductors does not exceed 20 percent of the interior cross-sectional area of the strut-type channel raceways.

Installation-**Securing and Supporting**

A. **Surface Mount**- A surface mount strut-type channel raceway shall be secured to the mounting surface with retention straps external to the channel at intervals not exceeding 3000 mm and within 900 mm of each outlet box, cabinet, junction box, or other channel raceway.

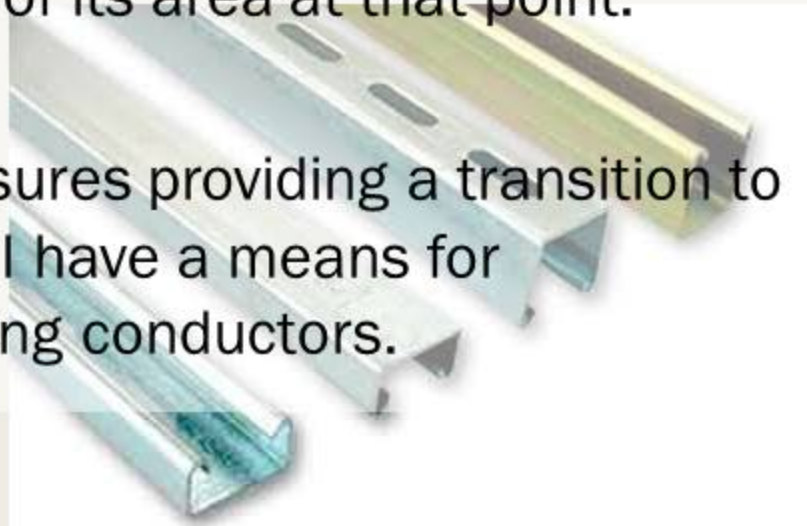
B. **Suspension Mount**- This raceway shall be permitted to be suspension mounted in the air with identified methods at the intervals same in surface mount, of channel raceway termination and ends.

Splice and Taps

- Splices and taps shall be permitted in raceways that are accessible after installation by having a removable cover. The conductors, including splices and taps, shall not fill the raceway to more than 75 percent of its area at that point.

Grounding

- Strut-type channel raceway enclosures providing a transition to or from other wiring methods shall have a means for connecting an equipment grounding conductors.



Construction specification-**Construction**

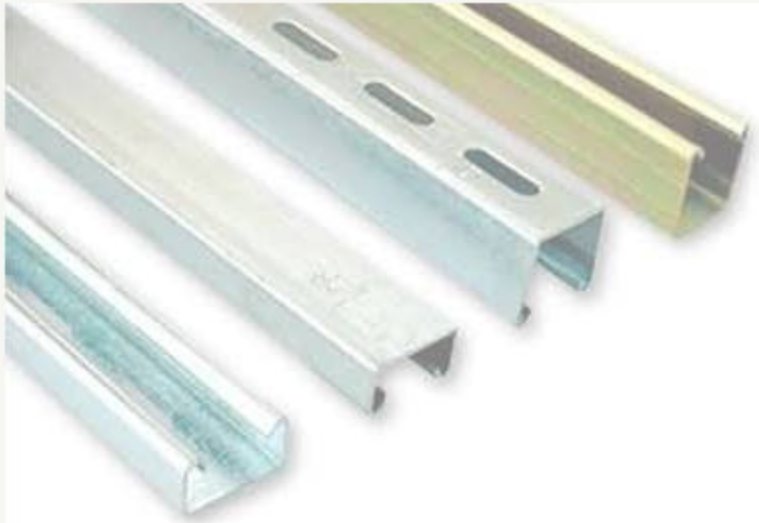
A. **Material**- Raceways and accessories shall be formed of steel, stainless steel, or aluminum.

B. **Corrosion Protection**- Steel raceways and accessories shall be protected against corrosion by galvanizing or by organic coating.

C. **Cover**- Covers of strut-type channel raceways shall be either metal or nonmetallic.

Construction specification-Marking

- Each length of strut-type channel raceway shall be clearly and durably identified as required in the first sentence of 1.10.1.21(A).



- ❑Surface Metal RAceways
- ❑Surface Nonmetal Raceways
- ❑Underfloor Raceways
- ❑Cable Trays

Surface Metal Raceways

- **Definitions**
  - Surface Metal Raceways. A metal raceway that is intended to be mounted to the surface of a structure, with associated couplings, connectors, boxes, and fittings for the installation of electrical conductors.

- **Listing Requirements**
  - Surface metal raceway and associated fittings shall be listed .

USES PERMITTED

1. In dry locations.
2. In class 1, Division 2 hazardous locations as permitted in 5.1.2.1 1(B)(3).
3. Under raised floors, as permitted in 6.45.1.5(E).
4. Extension through walls and floors.

USES NOT PERMITTED

1. Where subject to severe physical damage, unless otherwise approved.
2. Where voltage is 300 volts or more between conductors , unless the metal has a thickness of not less than 1.02mm.
3. Where subject to corrosive vapors.
4. In hoist ways.
5. Where concealed, except as permitted in 3.86.2.1.

- **Size of Conductors**
  - No conductor larger than that for which the raceway is designed shall be installed in surface metal raceway.
- **Number of Conductors**
  - The number of conductors or cables installed in surface metal raceway shall not be greater than the number for which the raceway is designed

a) The cross-sectional area of the raceway exceeds 2500 mm^2.

b) The current-carrying conductors do not exceed 30 in number

c) The sum of the cross-sectional areas of all contained conductors does not exceed 20 percent of the interior cross-sectional area of the surface metal raceway.

- **Securing and Supporting.** Surface metal raceways shall be supported at intervals in accordance with the manufacturer's installation instructions.
- **Splices and Taps.** Splices and taps shall be permitted in surface metal raceways having a removable cover that is accessible after installation. The conductors, including splices and taps, shall not fill the raceway to more than 75 percent of its area at that point.
- **Grounding.** Surface metal raceway enclosures providing a transition from other wiring methods shall have a means for connecting an equipment grounding conductor.
- **Combination Raceways.** When combination surface metallic raceways are used for both signaling and for lighting and power circuits.

Surface Nonmetallic Raceways

Surface Nonmetallic Raceway. A nonmetallic raceway that is intended to be mounted to the surface of a structure, with associated couplings, connectors, boxes, and fittings for the installation of electrical conductors.

Listing Requirements. Surface nonmetallic raceway and associated fittings shall be listed.

■ Uses Permitted

1. The use of surface nonmetallic raceways shall be permitted in dry locations.
2. Extension through walls and floors shall be permitted. Surface nonmetallic raceway shall be permitted to pass transversely through dry walls, dry partitions, and dry floors if the length passing through is unbroken.

Uses Not Permitted

1. Where concealed, except as permitted in 3.88.2.1(2).
2. Where subject to severe physical damage.
3. Where the voltage is 300 volts or more between conductors, unless listed for higher voltage.
4. In hoistways.
5. In any hazardous (classified) location except Class I, Division 2 locations as permitted in 5.1.2.1(b)(3).
6. Where subject to ambient temperatures exceeding those for which the nonmetallic raceway is listed.
7. For conductors whose insulation temperature limitations would exceed those for which the nonmetallic raceway is listed.

- **Size of Conductors.** No conductor larger than that for which the raceway is designed shall be installed in surface nonmetallic raceway.
- **Number of Conductors or Cables.** The number of conductors or cables installed in surface nonmetallic raceway shall not be greater than the number for which the raceway is designed. Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles.
- **Splices and Taps.** Splices and taps shall be permitted in surface nonmetallic raceways having a removable cover that is accessible after installation. The conductors, including splices and taps, shall not fill the raceway to more than 75 percent of its area at that point.

- **Grounding.** Where equipment grounding is required, a separate equipment grounding conductor shall be installed in the raceway.
- **Combination Raceways.** When combination surface nonmetallic raceways are used both for signaling and for lighting and 0power circuits, the different systems shall be run in separate compartments identified by stamping, imprinting, or color coding of the interior finish.
- **Construction.** Surface nonmetallic raceways shall be of such construction as will distinguish them from other raceways. Surface nonmetallic raceways and their elbows, couplings, and similar fittings shall be designed so that the sections can be mechanically coupled together and installed without subjecting the wires to abrasion.
- **Marking.** Surface nonmetallic raceways that have limited smoke-producing characteristics shall be permitted to be so identified.

UNDERFLOOR RACEWAYS

Uses Permitted

The installation of underfloor raceways shall be permitted beneath the surface of concrete or other flooring material or in office occupancies where laid flush with the concrete floor and covered with linoleum or equivalent floor covering

Not Permitted.

- where subject to corrosive vapors
- in any hazardous locations, except as permitted by 5.4.1.20 and in Class I, Division 2locations as permitted in 5.1.2.1
- Unless made of a material judged suitable for the condition or unless corrosion protection approved for the condition is provided, ferrous or nonferrous metal underfloor raceways, junction boxes, and fittings shall not be installed in concrete or in areas subject to severe corrosive influences.

Covering

a) **Raceways Not Over 100 mm (4 in.) Wide.**

Half-round and flat-top raceways not over 100 mm in width shall have not less than 19 mm of concrete or wood above the raceway.

b) **Raceways Over 100 mm Wide But Not Over 200 mm Wide.** Flat-top raceways over 100 mm but not over 200 mm wide with a minimum of 25 mm spacing between raceways shall be covered with concrete to a depth of not less than 25 mm. Raceways spaced less than 25 mm apart shall be covered with concrete to a depth of 40 mm.

Covering

c) **Trench-Type Raceways Flush with Concrete.** Trench-type flush raceways with removable covers shall be permitted to be laid flush with the floor surface. Such approved raceways shall be designed so that the cover plates provide adequate mechanical protection and rigidity equivalent to junction box covers.

d) **Other Raceways Flush with Concrete.** In office occupancies, approved metal flat-top raceways, if not over 100 mm in width, shall be permitted to be laid flush with the concrete floor surface, provided they are covered with substantial linoleum that is not less than 1.60 mm thick or with equivalent floor covering.

- **Size of Conductors.** No conductor larger than that for which the raceway is designed shall be installed in underfloor raceways.
- **Maximum Number of Conductors in Raceway.** The combined cross-sectional area of all conductors or cables shall not exceed 40 percent of the interior cross-sectional area of the raceway.
- **Splices and Taps.** Splices and taps shall be made only in junction boxes. For the purposes of this section, so-called loop wiring shall not be considered to be a splice or tap.
- **Discontinued Outlets.** When an outlet is abandoned, discontinued, or removed, the sections of circuit conductors supplying the outlet shall be removed from the raceway.

- **Laid in Straight Lines.** Underfloor raceways shall be laid so that a straight line from the center of one junction box to the center of the next junction box coincides with the centerline of the raceway system
- **Markers at Ends.** A suitable marker shall be installed at or near each end of each straight run of raceways to locate the last insert.
- **Dead Ends.** Dead ends of raceways shall be closed.
- **Junction Boxes.** Junction boxes shall be leveled to the floor grade and sealed to prevent the free entrance of water or concrete.

- **Inserts.** Inserts shall be leveled and sealed to prevent the entrance of concrete. Inserts used with metal raceways shall be metal and shall be electrically continuous with the raceway..
- **Connections to Cabinets and Wall Outlets.** Connections to Cabinets and Wall Outlets. Connections from underfloor raceways to distribution centers and wall outlets shall be made by approved fittings.
- **Ampacity of Conductors.** The ampacity adjustment factors, in 3.10.1.15(b)(2), shall apply to conductors installed in underfloor raceways.

CABLE TRAYS

Cable Tray System. A unit or assembly of units or sections and associated fittings forming a structural system used to securely fasten or support cables and raceways.

Uses Permitted. Cable tray shall be permitted to be used as a support system for service conductors, feeders, branch circuits, communications circuits, control circuits, and signaling circuits. Cable tray installations shall not be limited to industrial establishments. Where exposed to direct rays of the sun, insulated conductors and jacketed cables shall be identified as being sunlight resistant.

Wiring Methods

- **In Industrial Establishments.** For wiring methods permitted, single-conductor cables shall be permitted to be installed in accordance with:

a) Single-conductor cable shall be 50 mm2 or larger and shall be of a type listed and marked on the surface for use in cable trays. Where 50 mm2 through 100 mm2 single-conductor cables are installed in ladder cable tray, the maximum allowable rung spacing for the ladder cable tray shall be 230 mm.

b) Welding cables shall comply with the provisions of Part 6.30.4. Single conductors used as equipment grounding conductors shall be insulated, covered, or bare, and they shall be 22 mm2 or larger.

c) Single conductors used as equipment grounding conductors shall be insulated, covered, or bare, and they shall be 22 mm^2 or larger.

- Medium Voltage. Single- and multiconductor medium voltage cables shall be Type MV cable. Single conductors shall be installed in accordance with 3.92.1.3(b)(1).

- **Uses Not Permitted.**
  - a) **Strength and Rigidity.** Cable trays shall have suitable strength and rigidity to provide adequate support for all contained wiring.
  - (b) **Smooth Edges.** Cable trays shall not have sharp edges, burrs, or projections that could damage the insulation or jackets of the wiring.
  - (c) **Corrosion Protection.** Cable tray systems shall be corrosion resistant. If made of ferrous material, the system shall be protected from corrosion as required by 3.0.1.6.

(d) **Side Rails.** Cable trays shall have side rails or equivalent structural members.

(e) **Fittings.** Cable trays shall include fittings or other suitable means for changes in direction and elevation of runs.

(f) **Nonmetallic Cable Tray.** Nonmetallic cable trays shall be made of flame-retardant material.

Installation

- **Complete System.** Cable trays shall be installed as a complete system. Field bends or modifications shall be so made that the electrical continuity of the cable tray system and support for the cables is maintained
- **Through Partitions and Walls.** Cable trays shall be permitted to extend transversely through partitions and walls or vertically through platforms and floors in wet or dry locations.
- **Adequate Access.** Sufficient space shall be provided and maintained about cable trays to permit adequate access for installing and maintaining the cables

- **Completed Before Installation.** Each run of cable tray shall be completed before the installation of cables.
- **Supports.** Supports shall be provided to prevent stress on cables where they enter raceways or other enclosures from cable tray systems. Cable trays shall be supported at intervals in accordance with the installation instructions.
- **Covers.** In portions of runs where additional protection is required, covers or enclosures providing the required protection shall be of a material that is compatible with the cable tray.
- **Exposed and Accessible.** Cable trays shall be exposed and accessible except as permitted by 3.92.1.6(g).

- **Raceways, Cables, Boxes, and Conduit Bodies Supported from Cable Tray Systems.** In industrial facilities where conditions of maintenance and supervision ensure that only licensed electrical practitioner or non licensed electrical practitioner under the supervision of a licensed electrical practitioner service the installation and where the cable tray systems are designed and installed to support the load, such systems shall be permitted to support raceways and cables, and boxes and conduit bodies covered in 3.14.1.1.

Grounding

a) **Metallic Cable Trays.** Metallic cable trays that support electrical conductors shall be grounded as required for conductor enclosures in accordance with 2.50.5.7.

b) **Steel or Aluminum Cable Tray Systems.**

1) The cable tray sections and fittings shall be identified for grounding purposes.

2) The minimum cross-sectional area of cable trays shall conform to the requirements in Table 3.92.1.7

3) All cable tray sections and fittings shall be legibly and durably marked to show the cross-sectional area of metal in channel cable trays.

Cable Installation

- **Cable Splices.** Cable splices made and insulated by approved methods shall be permitted to be located within a cable tray, provided they are accessible and do not project above the side rails.
- **Fastened Securely.** In other than horizontal runs, the cables shall be fastened securely to transverse members of the cable trays.
- **Bushed Conduit and Tubing.** A box shall not be required where cables or conductors are installed in bushed conduit and tubing used for support or for protection against physical damage.

- **Connected in Parallel.** Where single conductor cables comprising each phase, neutral; or grounded conductor of an alternating-current circuit are connected in parallel as permitted in3.10.1.4, the conductors shall be installed in groups consisting of not more than one conductor per phase, neutral, or grounded conductor to prevent current imbalance in the paralleled conductors due to inductive reactance.
- **Single Conductors.** Where any of the single conductors installed in ladder or ventilated trough cable trays are 50 mm2 through100 mm2, all single conductors shall be installed in a single layer. Conductors that are bound together to comprise each circuit group shall be permitted to be installed in other than a single layer.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

a) Any Mixture of Cables. Where ladder or ventilated trough cable trays contain multi conductor power or lighting cables, or any mixture of multi conductor power, lighting, control, and signal cables, the maximum number of cables shall conform to the following:

   1) Where all of the cables are 100 mm2 or larger, the sum of the diameters of all cables shall not exceed the cable tray width, and the cables shall be installed in a single layer.

   2) Where all of the cables are smaller than 100 mm2, the sum of the cross-sectional areas of all cables shall not exceed the maximum allowable cable fill area in Column 1 of Table 3.92.1.9 for the appropriate cable tray width.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

3) Where 100 mm2 or larger cables are installed in the same cable tray with cables smaller than 100 mm2, the sum of the cross-sectional areas of all cables smaller than 100 mm2 shall not exceed the maximum allowable fill area resulting from the calculation in Column2 of Table 3.92.1.9 for the appropriate cable tray width.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

b) Multiconductor Control and/or Signal Cables Only. Where a ladder or ventilated trough cable tray having a usable inside depth of 150 mm or less contains multiconductor control and/or signal cables only, the sum of the cross-sectional areas of all cables at any cross section shall not exceed 50 percent of the interior cross-sectional area of the cable tray.

c) Solid Bottom Cable Trays Containing Any Mixture. Where solid bottom cable trays contain multiconductor power or lighting cables, or any mixture of multiconductor power, lighting, control, and signal cables.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

d) Solid Bottom Cable Tray —Where a solid bottom cable tray having a usable inside depth of 150 mm or less contains multiconductor control and/or signal cables only, the sum of the cross-sectional areas of all cables at any cross section shall not exceed 40 percent of the interior cross-sectional area of the cable tray. A depth of 150 mm shall be used to calculate the allowable interior cross-sectional area of any cable tray that has a usable inside depth of more than 150 mm.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

e) Ventilated Channel Cable Trays. Where ventilated channel cable trays contain multiconductor cables of any type, the following shall apply:

   1) Where only one multiconductor cable is installed, the cross-sectional area shall not exceed the value specified in Column 1 of Table 3.92.1.9(e).

   2) Where more than one multiconductor cable is installed, the sum of the cross-sectional area of all cables shall not exceed the value specified in Column 2 of Table 3.92.1.9(e).

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

f) Solid Channel Cable Trays. Where solid channel cable trays contain multiconductor cables of any type, the following shall apply:

1) Where only one multiconductor cable is installed, the cross- sectional area of the cable shall not exceed the value specified in Column 1 of Table 3.92.1.9(f).

2) Where more than one multiconductor cable is installed, the sum of the cross-sectional area of all cable shall not exceed the value specified in Column 2 of Table 3.92.1.9(f).

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

a) Ladder or Ventilated Trough Cable Trays. Where ladder or ventilated trough cable trays contain single-conductor cables, the maximum number of single conductors shall conform to the following:

   1) Where all of the cables are 500 mm2 or larger, the sum of the diameters of all single conductor cables shall not exceed cable tray width, and the cables shall be installed in a single layer.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

2) Where all of the cables are from 125 mm2 up to 500 mm2, the sum of the cross-sectional areas of all single-conductor cables shall not exceed the maximum allowable cable fill area in Column 1 of Table3.92.1.10(a) for the appropriate cable tray width.
3) Where 500 mm2 or larger single-conductor cables are installed in the same cable tray with single-conductor cables smaller than500 mm2, the sum of the cross-sectional areas of all cables smaller than 500 mm2 shall not exceed the maximum allowable fill area resulting from the computation.

Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.

b) Ventilated Channel Cable Trays. Where 50 mm, 75 mm, 100 mm, or 150 mm wide ventilated channel cable trays contain single-conductor cables, the sum of the diameters of all single conductors shall not exceed the inside width of the channel.

Multiconductor Cables

- **Multiconductor Cables.** The allowable ampacity of multiconductor cables, nominally rated 2 000 volts or less, installed according to the requirements of 3.92.1.9 shall be as given in Table3.10.1.16 and Table 3.10.1.18, subject to the provisions of (1), (2), (3),and 3.10.1.15(a)(2).

1. The derating factors of 3.10.1.15(b)(2)a shall apply only to multiconductor cables with more than three current-carrying conductors. Derating shall be limited to the number of current-carrying conductors in the cable and not to the number of conductors in the cable tray.

Multiconductor Cables

2. Where cable trays are continuously covered for more than 1.8m (6 ft) with solid unventilated covers, not over 95 percent of the allowable ampacities of Table 3.10.1.16 and Table 3.10.1.18 shall be permitted for multiconductor cables.

3. Where multiconductor cables are installed in a single layer in uncovered trays, with a maintained spacing of not less than one cable diameter between cables, the ampacity shall not exceed the allowable ambient temperature-corrected ampacities of multiconductor cables, with not more than three insulated conductors rated 0 through 2000volts in free air, in accordance with 3.10.1.15.

Single-Conductor Cables

- Single-Conductor Cables. The allowable ampacity of single-conductor cables shall be as permitted by 3.10.1.15(a)(2). The derating factors of 3.10.1.15(b)(2)(a) shall not apply to the ampacity of cables in cable trays. The ampacity of single-conductor cables, or single conductors cabled together (triplexed, quadruplexed, etc.), nominally rated 2000 volts or less, shall comply with the following:

Single-Conductor Cables

1) Where installed according to the requirements of 3.92.1.10,the ampacities for 600 kcmil and larger single-conductor cables in uncovered cable trays shall not exceed 75 percent of the allowable ampacities in Table 3.10.1.17 and Table 3.10.1.19. Where cable trays are continuously covered for more than 1 800 mm with solid unventilated covers, the ampacities for 325 mm2 and larger cables shall not exceed 70 percent of the allowable ampacities in Table 3.10.1.17 and Table 3.10.1.19.

Single-Conductor Cables

2) Where installed according to the requirements of 3.92.1.10,the ampacities for 50 mm2 through 125 mm2 single-conductor cables in uncovered cable trays shall not exceed 65 percent of the allowable ampacities in Table 3.10.1.17 and Table 3.10.1.19. Where cable trays are continuously covered for more than 1.8 m (6 ft) with solid unventilated covers, the ampacities for 50 mm2 through 250 mm2cables shall not exceed 60 percent of the allowable ampacities in Table3.10.1.17 and Table 3.10.1.19.

Single-Conductor Cables

3) Where single conductors are installed in a single layer in uncovered cable trays, with a maintained space of not less than one cable diameter between individual conductors, the ampacity of50 mm2 and larger cables shall not exceed the allowable ampacities in Table 3.10.1.17 and Table 3.10.1.19.

Single-Conductor Cables

4) Where single conductors are installed in a triangular or square configuration in uncovered cable trays, with a maintained free airspace of not less than 2.15 times one conductor diameter (2.15 × O.D.) of the largest conductor contained within the configuration and adjacent conductor configurations or cables, the ampacity of 50 mm2 and larger cables shall not exceed the allowable ampacities of two or three single insulated conductors rated 0 through 2 000 volts supported on a messenger in accordance with 3.10.1.15(b).

Number of Type MV and Type MC Cables (2001 Volts or Over) in Cable Trays.

a) Multiconductor Cables (2001 Volts or Over). The allowable ampacity of multiconductor cables shall be as given in Table 3.10.1.75and Table 3.10.1.76, subject to the following provisions:

   1) Where cable trays are continuously covered for more than1 800 mm with solid unventilated covers, not more than 95 percent of the allowable ampacities of Table 3.10.1.75 and Table 3.10.1.76 shall be permitted for multiconductor cables.

Number of Type MV and Type MC Cables (2001 Volts or Over) in Cable Trays.

2) Where multiconductor cables are installed in a single layer in uncovered cable trays, with maintained spacing of not less than one cable diameter between cables, the ampacity shall not exceed the allowable ampacities of Table 3.10.1.71 and Table 3.10.1.72.

Number of Type MV and Type MC Cables (2001 Volts or Over) in Cable Trays.

1) The ampacities for 50 mm2 and larger single-conductor cables in uncovered cable trays shall not exceed 75 percent of the allowable ampacities in Table 3.10.1.69 and Table 3.10.1.70. Where the cable trays are covered for more than 1 800 mm with solid unventilated covers, the ampacities for 50 mm2 and larger single-conductor cables shall not exceed 70 percent of the allowable ampacities in Table3.10.1.69 and Table 3.10.1.70.

Number of Type MV and Type MC Cables (2001 Volts or Over) in Cable Trays.

2) Where single-conductor cables are installed in a single layer in uncovered cable trays, with a maintained space of not less than one cable diameter between individual conductors, the ampacity of 50 mm2 and larger cables shall not exceed the allowable ampacities in Table 3.10.1.69 and Table 3.10.1.70.
3) Where single conductors are installed in a triangular or square configuration in uncovered cable trays, with a maintained free airspace of not less than 2.15 times the diameter (2.15 × O.D.)

- LOW-VOLTAGE SUSPENDED CEILING POWER DISTRIBUTION SYSTEM
- CONCEALED KNOB-AND-TUBE WIRING
- MESSENGER-SUPPORTED WIRING
- OPEN WIRING ON INSULATORS

BUSBAR

A noninsulated conductor electrically connected to the source of supply amd physically supported on an insulator providing a power rail for connection to utilization equipment, such as sensors, actuators, A/V devices, low-voltage luminaire assemblies, and similar electrical equipment.

BUSBAR SUPPORT

An insulator that runs the length of a section of suspended ceiling bus rail that serves to support and isolate the busbars from the suspended grid rail.

CONNECTOR

A term used to refer electromechanical fitting.

CONNECTOR LOAD

An electromechanical connector used for power from the busbar to utilization equipment.

GRID BUS RAIL

A combination of the busbar, the busbar support, and the structural suspended ceiling grid system.

LOW-VOLTAGE SUSPENDED CEILING POWER DISTRIBUTION

A system that serves as a support for a finished ceiling surface and consists of a busbar and busbar support system to distribute power to utilization equipment supplied by a class 2 power supply.

RAIL

The structural support for the suspended ceiling system typically forming the ceiling grid supporting the ceiling tile and listed utilization equipment, such as sensors, actuators, A/V devices and low voltage luminaires and similar electrical equipment.

REVERSE POLARITY PROTECTION

A system that prevents two interconnected power supplies, connected positive to negative, from passing current from one power source into a second power source.

SUSPENDED CEILING GRID

A system that serves as a support for a finished ceiling surface and other utilization equipment.

INSTALLATION

A. GENERAL REQUIREMENTS – Support wiring shall be installed in a neat and workmanlike manner. Cables and conductors installed exposed on the surface of ceilings and sidewalls shall be supported by the building structure in such a manner that the cable is not damaged by the normal building use. Such cables shall be supported by straps, staples, hangers, cable ties, or similar fittings designed and installed so as not to damage the cable.

INSTALLATION

B.) INSULATED CONDUCTORS – Exposed insulated secondary circuit conductors shall be listed, of the type, and installed as described as follows:

(1) Class 2 cable supplied by a listed class 2 power

(2) Wiring methods described in chapter 3

DISCONNECTING MEANS

A.) Location – A disconnecting means for the class 2 supply to the power grid system shall be located so as to be accessible and within sight of the class 2 power source for servicing or maintenance of the grid system.

B.) Multiwire Branch Circuits. – Where connected to a multiwire branch circuit, the disconnecting mean shall simultaneously disconnect all the supply conductors, including the grounded conductors.

SECURING AND SUPPORTING

A.) Attached to Building Structure – A suspended ceiling low-voltage power distribution system shall be secured to the mounting surface of the building structure by hanging wires, screws, or bolts in accordance with the installation and operation instructions.

B.) Attachment of Power Grid Rails – The individual power grid rails shall be mechanically secured to the overall ceiling grid assembly.

CONNECTORS AND ENCLOSURE

A. Connectors – Connections to the busbar grid rails, cables, and conductors shall be made with listed insulating devices, and these connections shall be accessible after installation. A soldered connection shall be made mechanically secure before being soldered. Others means of securing leads, such as push-on terminals and spade-type connectors shall be provide a secure mechanical connection.

B. Enclosures – Where made in a wall, connections shall be installed in an enclosure in accordance with Parts 3.14.1, 3.14.2, and 3.14.3.

OVERCURRENT AND REVERSE POLARITY PROTECTION

A.) Overcurrent Protection – The listed Class 2 power supply or transformer primary shall be protected at not greater than 20 amperes.

B.) Interconnection of Power Sources – Listed Class 2 power sources shall not have the output connections paralleled or otherwise interconnected unless listed for such interconnection.

SPLICES

A busbar splice shall be provided with insulation and mechanical protection equivalent to that of the grid rail busbars involved.

CONNECTIONS

Connections in busbar grid rails, cables and conductor shall be made with listed insulating devices and can be accessible after installation. Where made in a wall, connections shall be installed in an enclosure in accordance with parts 3.14.1, 3.14.2 and 3.14.3 as applicable.

GROUNDING

A.) Grounding of Supply Side of Class 2 Power Source. – The supply side of the class 2 power source shall be connected to an equipment grounding conductor in accordance with the applicable requirements in Part 2.50.4

B.) Grounding of Load side of Class 2 Power Source – Class 2 load side circuits for suspended ceiling low-voltage power grid distribution systems shall not be grounded.

Sizes and Types of conductors

1.) Load Side Utilization Conductors Size – Current-carrying conductors for load side utilization equipment shall be copper and shall be 0.75 mm^2 (1.0 mm dia) minimum.

2.) Power Feed Bus Rail Conductor Size – The power feed bus rail shall be 1.25 mm^2 (1.3 mm dia) min. or equivalent. For a busbar with a circular cross section, the diameter shall be 1.29 mm minimum and for other than circular busbars, area shall be 1.32 mm^2 minimum.

Uses Permitted

Concealed knob-and-tube wiring shall be permitted to be installed in the hollow spaces of walls and ceilings or in unfinished attics and roof spaces as provided by 3.94.2.14 only for extensions of existing installations.

Uses not permitted

Concealed know-and-tube wiring shall not be used in following

a) Commercial Garages

b) Theaters and similar locations

c) Motion Pictures studios

d) Hazardous (classified) locations

e) Hollow spaces of walls, ceilings and attics where such spaces are insulated by loose, rolled or foamed-inplace insulating material that envelops the conductors.

THROUGH OR PARALLEL TO FRAMING MEMBERS

Conductors shall comply with 3.98.17 where passing through holes in structural members. Where passing through wood cross members in plastered partitions, conductors shall be protected by non combustible, nonabsorbent, insulating tubes extending not less than 75 mm beyond the wood member.

CLEARANCES

A.) General – Clearance of not less than 75 mm shall be maintained between conductors and a clearance of not less than 25 mm.

B.) Limited Conductor Space. – Where space is too limited to provide these minimum clearances, such as at meters, panelboards, outlets, and switch points, the individual conductors shall be enclosed in flexible nonmetallic tubing, which shall be continuous in length between the last support and the enclosure or terminal point.

C.) Clearance from piping to Exposed Conductors, and so forth. – Conductors shall comply with 3.98.2.10 for clearances from other exposed conductors, piping, and so forth.

IN ACCESSIBLE ATTICS

A.) Accessible by Stairway or Permanent ladder. – Conductors shall be installed along the side of or through bored holes in floor joists, studs or rafters.

B.) Not Accessible by stairway or permanent ladder. – Conductor shall be installed along the sides of or through bored holes in floor joists, studs or rafters.

SECURING AND SUPPORTING

A.) Supporting – Conductors shall be rigidly supported on noncombustible, nonabsorbent insulating materials and shall not contact any other objects. Support shall be installed as follows:

a) Within 150mm of each side of each tap or splice and;

b) At intervals not exceeding 1400mm.

B.) Securing – Where solid knobs are used, conductors shall be securely tied thereto by tie wires having insulation equivalent to that of the conductor.

DEVICES

Switches shall comply with 4.4.1.4 and 4.4.1.10(B)

SPLICES AND TAPS

Splices shall be soldered unless approved splicing devices are used. In line or strain splices shall not be used.

MESSENGER-SUPPORTED WIRING

A expose wiring support system using a messenger wire to support insulated conductors by any one of the following:

1. A messenger with rings and saddles for conductor support
2. A messenger with field-installed lashing material for conductor support
3. Factory Assembled aerial cable
4. Multiplex cables utilizing a bare conductor, factory assembled and twisted with one or more insulated conductors, such as duplex, triplex or quadruplex type of connection

Uses Permitted

A.) Cable Types – The cable Types in Table 3.96.2.1(A) shall be permitted to be installed in messenger-supported wiring under the conditions described in the article or section reference for each.

B.) In Industrial Establishments. – where conditions of maintenance and supervision ensure that only qualified persons service the installed messenger-supported wiring, the following shall be permitted:

1) Any of the conductor types shown in Table 3.10.3.1(A) or Table 3.10.3.1(B)

2) MV cable

C.) Hazardous (classified) locations – Shall be permitted to be used in hazardous locations where the contained cables and messenger-supported wiring are specifically permitted by other articles in this Code.

Uses not permitted

Messenger-supported wiring shall not be used in hoistways or where subject to physical damage.

MESSENGER

A.) Support – The messenger shall be supported at dead ends and at intermediate locations so as to eliminate tension on the conductors. The conductors shall not be permitted to come into contact with the messenger supports or any structural members, walls, or pipes.

1. Neutral Conductor – Where the messenger is used as a neutral conductor, it shall comply with the requirements of 2.25.1.4, 2.50.10.5(A), 2.50.10.5(B) and 2.50.10.8(B)

2. Equipment Grounding Conductor. – Where the messenger is used as an equipment grounding conductor, it shall comply with the requirements of 2.50.2.13(B), 2.50.6.9, 2.50.10.5(B)(8) and 2.50.10.8(D)

CONDUCTOR SPLICES AND TAPS

Conductor splices and taps made and insulated by approved methods shall be permitted in messenger-supported wiring.

GROUNDING

The messenger shall be grounded as required by 2.50.4.1 and 2.50.4.7 for enclosure grounding.

OPEN WIRING ON INSULATORS

A exposed wiring method using cleats, knobs, tubes, and flexible tubing for the protection and support of single insulated conductors run in or on buildings.

Uses Permitted

Open wiring on insulators shall be permitted only for industrial o
agricultural establishments on systems of 600 V, nominal or less
as follows:

1) Indoor or outdoor

2) In wet or dry locations

3) Where subject to corrosive vapors

4) For services

Uses not permitted

Open wiring on insulators shall not be installed where concealed by the building structure.

EXPOSED WORK

A.) Dry Locations – where not exposed to physical damage, conductors shall be permitted to be separately enclosed in flexible nonmetallic tubing. The tubing shall be in continuous lengths not exceeding 4 500 mm and secured to the surface by straps at intervals not exceeding 1400 mm.

B.) Entering Spaces Subject to Dampness, Wetness, Corrossive Vapors. – Shall have drip loops formed on them and shall then pass upward and inward from the outside of the buildings or from the damp, wet or corrosive location, through noncombustible, nonabsorbent insulating tubes.

C.) Exposed to Physical Damage – Conductors within 2100 mm from the floor shall be considered exposed to physical damage.

THROUGH or PARALLEL TO FRAMING MEMBERS

Open conductors shall be separated from contact with walls, floor, wood cross members, partitions through which they pass by tubes or bushings of noncombustible, nonabsorbent insulating material.

CLEARANCES

Open conductor shall be separated at least 50 mm from metal raceways, piping, or other conducting material, and from any exposed lighting, power or signaling conductor shall be separated there from by a continuous and firmly fixed nonconductor in addition to the insulation of the conductor.

IN ACCESSIBLE ATTICS

Conductors in unfinished attics and roof spaces shall comply with 3.98.2.14(A) or (B)

A.) Accessible by Stairway or Permanent Ladder – Conductors shall be installed along the side of or through bored holes in floor joists, studs or rafters. Where run through bored holes, conductors in the joists and in studs or rafters to height of not less than 2100 mm above the floor or floor joists shall be protected by substantial running boards extending not less than 25 mm on each side of the conductors.

B.) Not Accessible by Stairway or Permanent Ladder. – Conductors shall be installed along the sides of or through bored holes in floor joists, studs or rafters.

SECURING AND SUPPORTING

A.) Conductors Sizes Smaller than 8.0 mm2 (3.2 mm dia.) - Conductors smaller than 8.0 mm2 (3.2 mm dia.) shall be rigidly supported on noncombustible, non absorbent insulating materials and shall not contact any other objects. Support shall be installed as follows:

1) Within 150 mm from a tap or splice

2) Within 300 mm of a dead end connection to a lampholder or receptacle

3) At intervals not exceeding 1400 mm and at closer intervals sufficient to provide adequate support where likely to be disturbed

B.) Conductors Sizes 8.0 mm2 (3.2 mm dia.) and Larger. – Supports 8.0 mm2 (3.2 mm dia.) or larger installed across open spaces shall be permitted up to 4500 mm apart if noncombustible, nonabsorbent insulating spacers are used at least every 1400 mm to maintain at least 65 mm between conductors.

C.) Industrial Establishments – Where conditions of maintenance and supervision ensure that only qualified persons service the system, conductors of sizes 125 mm2 and larger shall be permitted to be run across open spaces where supported at intervals up to 9000 mm apart.

D.) Mounting of Conductor Supports - Where nails are used to mount knobs, they shall not be smaller than ten-penny. Where screws are used to mount cleats, they shall be of a length sufficient to penetrate the wood to a depth equal to at least ½ the height of the knob and the full thickness of cleat. Cushion washers shall be used with nails.

E.) Tie Wires – Conductors 8.0 mm2 (3.2 mm dia.) or larger and supported on solid knobs shall be securely tied thereto by tie wires having insulation equivalent to that of the conductor.

DEVICES

Surface type snap switches shall be mounted in accordance with 4.4.1.10(A) and boxes shall not be required. Other type Switches shall be installed in accordance with 4.4.1.4

OUTDOOR OVERHEAD CONDUCTORS OVER 1000 VOLTS

OUTDOOR OVERHEAD CONDUCTORS OVER 1000 VOLTS

Outdoor Overhead Conductors: Single conductors, insulated, covered or bare, installed outdoors on support structures in free air.

Uses Permitted:

Outdoor overhead conductors over 1000 volts, nominal, shall be permitted only for systems rated over 1000 volts, nominal, as follows,

- a.) Outdoors in free air
- b.) For service conductors, feeders or branch circuits

SUPPORT:

A.) Conductors – Documentation of the engineered design by a licensed electrical practitioner engaged primarily in the design of each systems for the spacing between conductors shall be available upon request of the office of the building official/EE and shall include considerations of the following:

1. Applied Voltage
2. Conductor Size
3. Distance between support structures
4. Type of Structure
5. Wind loading
6. Surge protection

SUPPORT:

B.) Structures – Structures of wood, metal, concrete or combinations of those materials shall be provided for support of overhead conductors over 1000 volts nominal. Documentation of the engineered design by a licensed engineer engaged primarily in the design of such systems be available upon request of the Office of the Building Official/EE and shall include considerations of the following:

1. Soil Conditions
2. Foundations and structure settings
3. Weight of all supported conductors and equipment

SUPPORT:

4. Weather loading and other conditions such as but not limited to, ice, wind, temperature, and lightning.

5. Angle where change of direction occurs

6. Space between adjacent structures

7. Effect of dead end structures

8. Strength of guys and guy anchor

9. Structure size and material(s)

10. Hardware

SUPPORT:

C.) Insulators – Insulators used to support conductors shall be rated for all of the following:

1. Applied phase-to-phase voltage
2. Mechanical strength required for each individual installation
3. Impulse withstand BIL in accordance with Table 4.90.2.4

THANK YOU!